POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

Contents

In the Light of Modern Development 550
With the Editors 551
Control Is the Secret of Plant Performance.
Tempest in a Teapot.
Albert Lea's Finest. By Harry Vaughan 552
Valve Setting DeLuxe. By E. M. Paullin 556
Mechanism of Heat Transfer by Evaporation. By Allen G. Stimson 559
Power Interchange. By B. Winger 563
Limiting Factors for High Steam Temperature.
By Sabin Crocker and Harvey A. Wagner 565
The Early History of Steam Generation. By Pulverizer Pete's Stooge 569
Sewage Makes Good Power. By C. E. Wahlstrom and H. T. Rudgal 571
Diesel Cooling Water Supplies. By Gustave J. Bischof 574
Electron Tubes—Principles and Applications. Part XXIX.
By A. W. Kramer 576
Reliability—First Requirement of Steam Generating Equipment 579
A Different Monthly Bill Chart. By Joseph J. Curry 580
Shall Grand Coulee and Bonneville Send Power to New York? 583
Pictures of Engineering Interest 586
Turbine Room Changes at Austin.
By Carroll L. Elliott and Joseph V. Edeskuty 588
Modern Turbines. By L. E. Newman 591
Paper Mill Digester 594
Feedwater Heaters Will Work. By Julius Brodsky 595
Industrial Efficiencies Advance with Redesigned Equipment 596
'Round About with the Engineering Editor 597
Readers' Conference 598
New Equipment 603
News from the Field 607
For the Engineers' Library 610
New Engineering Books 612
Power Plant Construction News 614

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

SEPTEMBER
1938

Vol. XLII., No. 9

Published on the first of each month, copyright 1938 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editorial Director R. E. TURNER, Editor.
A. W. KRAMER, Electrical Editor RICHARD H. MORRIS, Engineering Editor.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.

In the Light of Modern Development

THIS WORKMAN is smoothing out the irregularities on the inside surface of one of the two new 115,000 hp. hydraulic turbines for Boulder Dam now under construction at the Allis-Chalmers Plant in Milwaukee, Wis. Six such 115,000 hp. main units have already been installed at this huge government project and the installation of these two new ones will bring the total capacity almost to a MILLION HORSEPOWER—a world record for capacity.

Much has been said and written regarding the wisdom of building this and other plants of a similar nature, much of the criticism being directed at the lack of load in the vicinity of the plants. Whatever justification there may be for this criticism nobody can forsee how future conditions may alter the situation. At the present time it is uneconomical to transmit power over distances greater than three hundred miles, but in the light of modern development it is by no means certain that these limits will hold in the future. Various researches and developments are under way which may profoundly alter the transmission problem.

One far-seeing individual at least is unwilling to accept the present limitations regarding distance of transmission as final. In an address before the Seattle Engineers' Club recently, J. D. Ross, administrator of the Bonneville Project, outlined a bold plan for sending power from the federal hydro plants in the northwest, east to Chicago and New York and doing it economically. This plan of straddling the nation with a coast to coast power bus is startling in its implications, but by no means a dream impossible of realization. Good politician that he is, J. D. Ross is at the same time too experienced and too practical an engineer to be regarded as a half baked visionary. The details of his plan are described in other pages of this issue.

WITH THE EDITORS

Control Is the Secret of Plant Performance

AT THE INSTANT an archer releases the string to his bow, he loses all control over the course which the arrow may follow. Gravity, air resistance, wind velocity and direction, and the individual characteristics of the arrow are the principal factors the effects of which the archer must judge instantaneously when he points his arrow and draws his bow string to the proper tension. The point is that for at least a fraction of a second he loses control of the arrow's course regardless of how scientifically his implements have been made.

Power plant equipment may be built of the finest materials, along designs that have given highest efficiencies in practical application, but when the manufacturer turns his installed equipment over to the operating force he loses personal control over the results to be secured, just as does the archer over his arrow or a base ball pitcher the instant the ball leaves contact with his fingers. The comparison, however, ends right there, for in the power plant the operating personnel guides, directs and controls the energy conversions through the plant and it is upon these engineers that the owner of the plant must depend for the results secured.

Here the personal equation is the governing factor and although this equation has never been accurately formulated, it may be said to be made up of two elements—knowledge and character. Knowledge is that mental capacity which informs the individual as to facts and results of combinations of conditions. Character is that quality which directs the will of the individual. The man in charge of operation must have both knowledge to solve the problems of his occupation and the character to see that his responsibilities are properly executed at the correct time and with due accuracy. Lacking either of these qualifications should disqualify a man for a responsible position as a power plant operator.

Qualifications for a plant operator are distinct from those of a designer, a research technician or a scientist. His work may be classed as that of an observer with a hundred and one controls at his finger tips to maintain correct conditions for each variation in conditions outside his personal control. He must be a realist taking conditions as they are and improving them as best he can. He has no dreams of a frictionless bearing, energy conversion without a loss, perpetual motion. He accepts no idea just for the sake of argument. A heating bearing must be cooled or it will destroy itself; incorrect CO_2 is inefficient combustion; high flue gas temperature means costly energy flung to the winds. He is a detective hunting and stopping losses. All his senses and available instruments must be attuned to the plant in which he is working. The operating personnel is in fact the brains of the plant, responding to its every need from food and drink to the binding up of wounds and nursing through fevers.

Power plant performance is thus a result of the choice of equipment and the selection of the men to operate that equipment. These elements do not work in parallel, for one begins where the other leaves off; nor can the finest equipment eliminate entirely the services of men to keep it in the pink of condition.

If manufacturers wish their equipment to stand up well in performance, it behooves them to inform the operators not only on the general principles but the details of their equipment. Plant owners who wish to secure power requirements at the least possible cost will not only secure the most reliable and efficient equipment commercially obtainable for their purposes but will see to it that that equipment is placed in charge of an operating force that is as humanly reliable and efficient as the equipment. They will also look carefully to their employment relations with the operating force; these must be satisfactory in order to secure loyalty and inspire operators to be alert in their duties.

Tempest in a Teapot

ALL HOT and bothered over the proper term to use in connection with the heating value of a fuel, Committee E-8 of the A.S.T.M. has appealed to the industry for help in making a decision. In the past, such terms as B.t.u. value, thermal value, heat of combustion, calorific value, etc., have been used. Because a calorimeter is used in the determination, calorific value is perhaps the most widely accepted, has been adopted by the British Standards Institution, is similar to the "pouvoir calorifique" of the French and "heizwert" of the German, and is favored by the majority of the Committee. Unfortunately, the committee does not see as one, however, and a minority report holds out for "heat of combustion" as more logical.

The broadminded attitude of the committee in asking for outside comments and suggestions is commendable but the point in question hardly justifies the commotion. Many engineering terms have little or no etymological or logical justification yet answer the purpose quite nicely. Standardization is important, yet to be popular and widely accepted, standards must be popular and subject to adoption with the minimum change in established habit.

Concise, already widely used, and more or less internationally accepted, calorific value has practical advantages which compensate for limitations in its family tree. Standards are of value only when used and as far as nomenclature is concerned, it makes no difference whether the derivation is Chinese, Hebrew or Latin as long as everyone understands its meaning. There are still too many major engineering problems unsettled to quibble about irrelevant details.

Wilson & Co. completes new power plant with three 40,000 lb. per hr., 350 lb. pulverized coal fired boilers and three extraction-back-pressure turbines totaling 3000 kw.

ALBERT LEA'S FINEST

By HARRY VAUGHAN
Chief Engineer of Power Plant
Wilson & Co., Albert Lea, Minn.

SELDOM DOES a power plant receive the architectural treatment necessary to class it as a civic asset and the new Wilson & Co. plant at Albert Lea, Minn., is probably the only one ever to be mentioned as the finest building in town. This is no reflection on the rest of Albert Lea, a thriving modern city proudly tracing its origin back to the days when Minnesota was the frontier, for the plant is an imposing structure quite in keeping with the interior design. Wilson & Co. handling its own design work has always given adequate attention to the ever growing packing house steam and power requirements, and, with years of operating experience as a background have built into this plant all the flexibility necessary to give a proper steam and power balance.

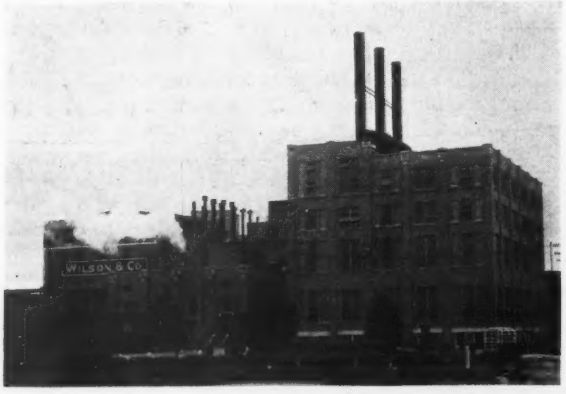


Fig. 1. An exterior view of the plant. The boiler room and turbine room are divided by a railroad spur. The turbine room is a single story building visible just under the last part of Wilson & Co. It is an extension of the old boiler room from which the boilers have been removed to give additional space for compressors and pumps. Electric power was formerly purchased

Due to space limitations, the new plant, built to replace an old boiler room and purchased power, is in two sections, a turbine room with one 500, one 1000 and one 1500 kw. units forms an extension to the old plant while the new boiler room with three 40,000 lb. per hr. boilers is across the tracks but connected with the turbine room by a tunnel. Removal of the old boilers gave much needed room for expansion of the old engine room, with ice machines, air compressors, brine, hot and cold water pumps. To insure reliability and facilitate balancing power and steam, practically all auxiliaries are in duplicate with one steam and one motor driven unit.

Refrigeration capacity totaling some 600 t. consists of a: 100 t. York Corliss driven machine; one 150 and one 300 t. Vilter units driven by Electric Machinery motors and a 50 t. Vilter booster driven by a Troy Engberg engine. All steam drives and pumps exhaust into the 10 lb. system. Some of the pumps, in general the old ones, operate from the 75 lb. system but the newer units, including the ice machine and new power plant auxiliaries, are supplied from the 135 lb. system.

Quite aside from the possibility of adjusting the steam-power balance by means of the duplicate drives, the provision for insuring a positive supply of steam to each system with the maximum production of by-product power, is one of the unusual features of the plant. This involves both the steam and electrical ends as shown by Figs. 6 and 7. The three turbines are arranged for different combinations of extraction and exhaust pressures and the electrical bus is sectionalized so that the various feeder circuits can be divided and each generating unit can carry a portion of the load as an independent system.

For this reason each unit is provided with a generator panel and exciter panel and an individual voltage regulator. If desired these sections can of course be tied together and the three machines run in

parallel. A mimmic bus on the switchboard, made of copper strips and visible in Fig. 2 precludes the possibility of operating the wrong switch, for the operator has before him a complete picture of the system. With the exception of an Esterline-Angus recording wattmeter, the switchboard, electrical instruments and switchgear were all supplied by Westinghouse. A Philco storage battery for the control circuits and emergency excitation of the synchronous motors, a 5 kw. Westinghouse battery charger and the Transite cell structure are in the basement directly below the switchboard. Turbine oil pressure is regulated by Mason-Neilan regulator and a Sharples unit is provided for periodic centrifuging. A 10 t. Whiting crane serves the turbine room.

To take care of emergencies and to maintain pressure in all systems under all conditions, Swartwout pressure reducing stations are provided as shown by Fig. 6, and grouped on the engine room wall. Between the 335 and 135 lb. systems the reducing valve is followed by a desuperheater to protect the older equipment against excessive superheat. This is paralleled with a duplicate system in the new boiler room, set to operate at 133 lb. instead of 135 lb. It is apparent that the primary object of the designers was reliability of service under all conditions.

The new turbo-generators are all General Electric 3600 r.p.m., 3 ph., 60 cycle, 2400 v. units with direct connected exciters. Except for the 2400 v. motors driving the compressors, 440 v. motors are used throughout the plant, power being distributed at 2400 v., to six step down transformer stations around the plant. Some of these were installed during the days of purchased power but two banks of Allis-Chalmers transformers were installed to take care of the new power plant.

This building, independent of the rest of the plant, houses three 350 lb., 525 deg. F. Combustion Engineering bent tube boilers with a normal steaming capacity of 40,000 lb. per hr. Each boiler has a 400 sq. ft. Elesco superheater, a 7900 sq. ft. tubular air heater, an American Blower forced and induced draft fan and is fired with pulverized coal from a Kennedy-Van Saun ball mill, through two water cooled burners.

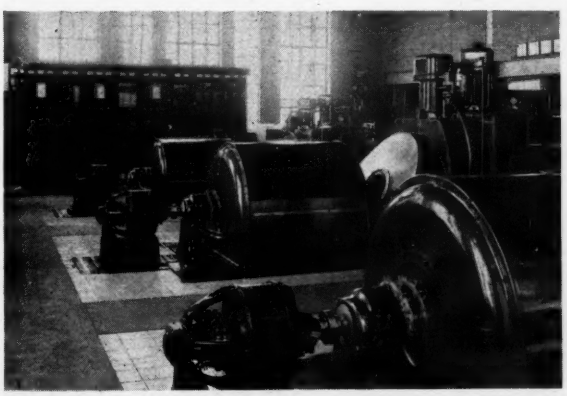


Fig. 2. View of the turbine room. Notice the mimic bus on the switchboard. The bus can be sectionalized so that the plant load can be divided into blocks and carried by the turbines in accordance with heat balance requirements. The turbines are built in different combinations of extraction and back pressure so as to give a flexible arrangement to meet varying requirements of the 135, 75 and 10 lb. steam systems

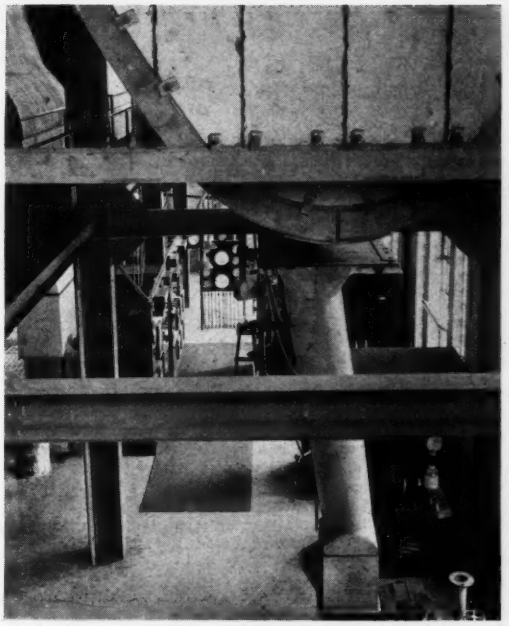


Fig. 3. View from the laboratory balcony over the office showing the precast concrete slab coal bunker in the foreground with the coal scales below, the control panels in the center and the air duct, to the pulverizer in the basement, on the extreme right

The general arrangement of the plant is shown by the cross section, Fig. 5. Both the forced and induced draft fans are located on the top floor and each is driven through a hydraulic coupling by Allis-Chalmers synchronous motors with Cutler Hammer starters. Induced draft fans, of the cinder eliminating type, rated at 35,200 c.f.m., at 5.26 in. and 350 deg. F. and driven by 75 hp. motors take their suction directly from the top of the air heater and discharge vertically to short steel stacks supported on the building steelwork. Cinders eliminated drop through a cyclone to a hopper from which they are removed by the United pneumatic ash handling system which discharges to an outdoor ash hopper. Both the air heater and induced draft fan can be bypassed by the Y shaped duct shown in Fig. 4.

Forced draft fans, rated at 25,200 c.f.m., at 7.14 in. and 195 deg. F. and driven by 60 hp. motors and located on the opposite side of the boilers, take their suction from the top of the boiler room and discharge through a duct running across the top of each boiler to the air heater.

Pulverizers located in the basement are driven by 50 hp. Westinghouse line start motors through D. O. James speed reducers and the exhausters by 15 hp. Westinghouse motors of the same type. Each boiler has two watercooled burners designed by Wilson & Co. engineers and in addition a Peabody oil burner for lighting off and emergency use. Two Quimby fuel oil pumps located in the basement have a capacity of 15 g.p.m. each at 275 lb. pressure. One is driven by a 7½ hp. Reliance motor, the other by a 4 cyl. Continental engine through a Twin Disc clutch.

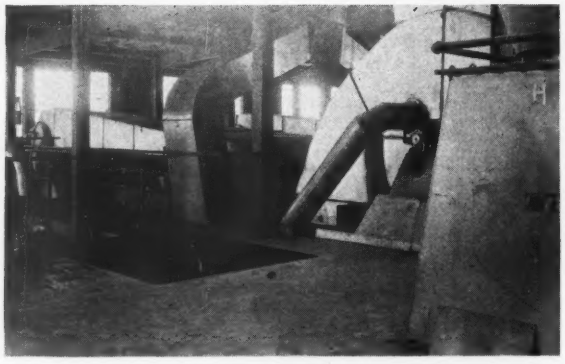


Fig. 4. View from the fan floor of the boiler tops. The induced draft fans on the right take their suction from the top of the vertical tubular air heater and discharge to a steel stack supported on the building steelwork. The Y shaped duct is a bypass around the air heater and induced draft fan. It enters the base of the stack just above the roof as shown in the exterior view, Fig. 1. The forced draft fan at the left discharges into a duct which comes across the top of the boiler to the air heater. At the extreme right can be seen the base of the cyclone on the pneumatic coal elevating system

Each furnace has a volume of 3935 cu. ft., with the Detrick Detred walls partially water cooled by 1050 sq. ft. of bare tubes on the back walls and 7 rows of tubes on each side wall. Double ash hoppers are used with ash removal by a United pneumatic conveying system. Boiler appurtenances include: Golden-Anderson stop and check valves; Yarway water columns, gage glasses, blowoff valves; Powell, Walworth and Crane steam valves; Swartwout S-C regulators; Detrick fire doors; Hays-Carrick damper control on primary and secondary air; Diamond soot blowers and a continuous system of filtering boiler water.

With the exception of damper regulators to proportion primary and secondary air, combustion control equipment is not used but remote control of all auxiliaries is provided from a central control station on the operating floor and visible between the coal bunkers in Fig. 3. One panel of Star Brass indicating gages shows steam, water and oil pressures common to the plant while individual control panels give a complete picture and operating record of each of the three boilers.

These panels have a Republic CO_2 recorder and water flow meters; Bailey boiler meters; Hays 8 pointer draft gages; six Taylor multipen recorders for various steam, water, air and gas temperatures and pressures; and Westinghouse electrical indicating instruments necessary for the forced and induced draft fan, the pulverizer feeders and exhausters. The fan motor starting cubicles are on the main floor just back of the control panels and can be seen just back of the coal spout in Fig. 3.

The coal handling system itself is unusual. The Freeman Riff, 200 t. coal bunker is of precast concrete slab construction and is totally enclosed. From the cars coal is unloaded and elevated by a United pneumatic system using a Roots-Connersville blower, V-belted to a 100 hp. Allis-Chalmers motor, as an exhauster. From the cyclone of this system, the coal drops down to a S-A Redler conveyor for distribution in the bunker. The conveyor is driven by a 7½ hp. Allis-Chalmers motor through Falk gears. From the bunker coal feeds by gravity through Richardson scales on the main floor to the pulverizer feeders in the basement. These feeders are driven by Westinghouse Type FS, ¾ hp. a.c. motors.

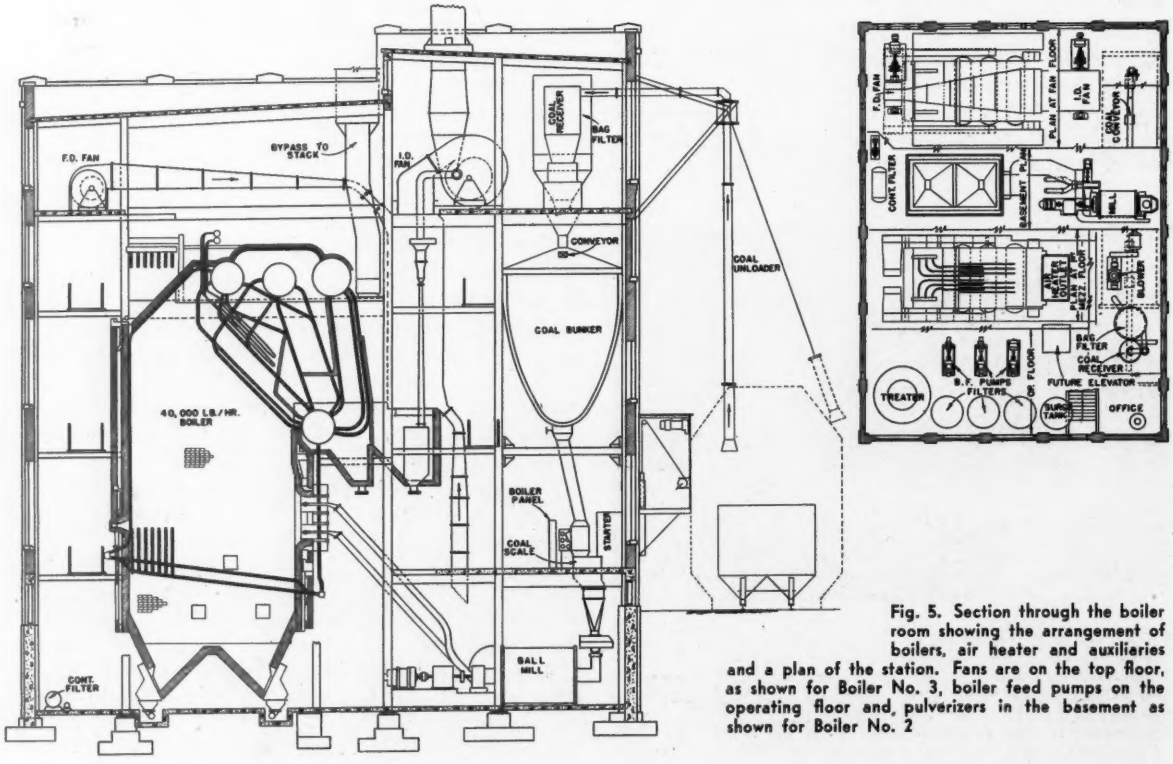


Fig. 5. Section through the boiler room showing the arrangement of boilers, air heater and auxiliaries and a plan of the station. Fans are on the top floor, as shown for Boiler No. 3, boiler feed pumps on the operating floor and, pulverizers in the basement as shown for Boiler No. 2

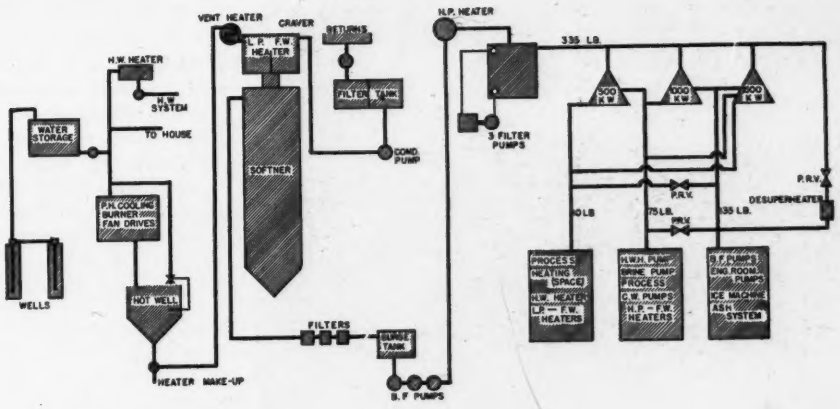


Fig. 6. Flow diagram of the water and steam systems

Three 165 g.p.m., 1040 ft. head, 3600 r.p.m. Worthington boiler feed pumps are also located on the main operating floor. One is driven by a 100 hp. Allis-Chalmers motor, the other two by 85 hp. Westinghouse turbines. Only about 25 per cent of the boiler feed is condensate return and the rest is taken from the general plant system as shown by Fig. 6. All water used is pumped from one of two deepwells by Byron Jackson motor driven pumps which discharge to a cold water storage tank in the old engine room from which it is repumped to the plant for all purposes. This includes water for the hot water system and the power plant. The former consists of a Wilson designed heater with a Taylor Fulscope controller to maintain a temperature of 144 deg. F. and two Gardner Denver 750 g.p.m., 120 ft. head circulating pumps, one driven by a 30 hp. Allis-Chalmers motor, the other by a G.E. 50 hp. turbine. This water is treated by National Aluminate Co. A-B treatment to prevent pipe line corrosion.

Cooling water for the burners and oil coolers in the boiler room is returned to a hotwell in the boiler room which serves as a suction tank for the makeup water. The level in this hotwell is maintained from the plant water supply system by a MacAlear float control. Makeup water, pumped through a Graver vent condenser to a two compartment low pressure heater, passes to a settling tank for treatment and then through filters to a surge or cushion tank. From this the boiler feed pumps take their suction, and pump through a high pressure heater to the boilers. Filters and the surge tank are located on the main floor next to the boiler feed pumps but all auxiliary pumps, including the fuel oil equipment, are located in the basement with the motor control centralized in a 10 unit Bulldog auxiliary panel.

The building itself is of brick, glass brick panes, steel and concrete construction with a flat roof of concrete slabs insulated by 2 in. of Temlock. The engineer's office is on the main floor, with showers, locker rooms and laboratory on the second. This laboratory is unusually well equipped for all routine water and coal testing. The engineering work was handled by the company's engineering department of which Allen McKenzie is chief engineer and J. M. Lenone designing engineer. Harry H. Sopp is master mechanic of the Albert Lea plant.

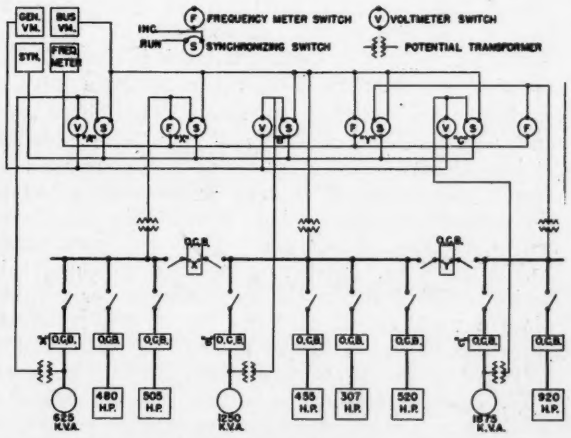


Fig. 7. Schematic diagram and synchronizing scheme showing the three turbo generators, two bus sectionalizing breakers and six individual feeder circuits.

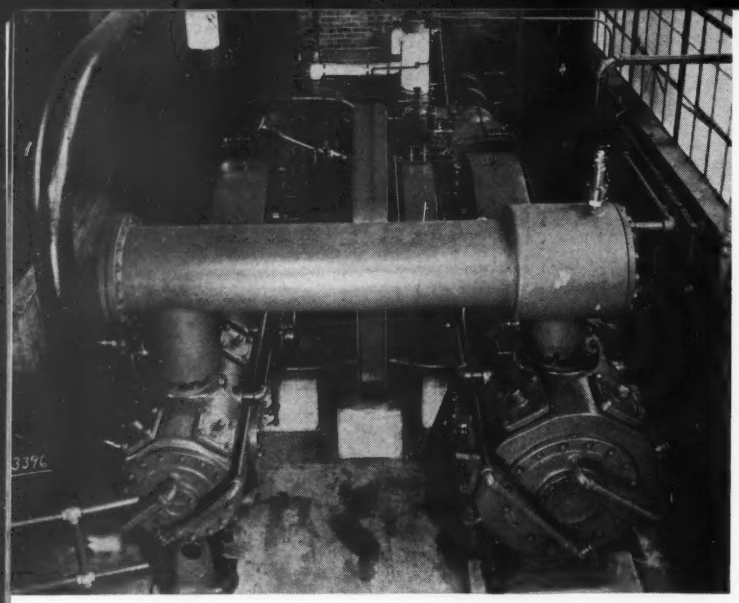
This allows sectionalizing the bus through the bus tie breakers permitting operation of each generator and its feeders, as a separate system or in parallel, each generator having its own Westinghouse Vibrating type voltage regulators.

This sectionalizing is particularly necessary for the bus section of the 1875 kv-a. generator and its motor circuits for the plant refrigeration. These motors are synchronous motors and the 450 hp. unit has 900 kv-a. inrush at starting, and would tend to lower the voltage on the different plant feeders. Therefore, this motor will always be started from the 1875 kv-a. generator with the bus tie breaker open.

Atom Smasher

COMPLETION of a cyclotron atom-smasher now under construction at Harvard University will mark another advance in the study of atomic structure by means of atomic disintegration produced by high voltage. The machine will be one of the largest of its kind in the world and is expected to generate atom-smashing projectiles of 8,000,000-volt energy and above, permitting the most precise measurements ever made of the forces released by atomic disintegration. It will be put in operation probably by early summer.

This is the third of such machines which have been partially built by General Electric. Two years ago, two coils were made for a unit at the University of Rochester and an oscillator was made for another cyclotron at Princeton University. The pole cores of the Harvard cyclotron are two times greater in diamter than those of the machine at Rochester, and will give four times as much magnetic flux.



An opposed steam driven compressor with the steam end at the back. A close-up of the governor, visible just to the right of the flywheel rim, is shown by Fig. 2 and diagrammatically by Fig. 3

It has been a long time since we have had occasion to present a valve setting article and we trust this one will give the old timers something to chew over and show the beginners that the steam engine is still very much in the picture. The article gives complete directions for setting the double piston valve used on the Worthington opposed type steam driven compressors and tells how the automatic cutoff governor works.

Valve Setting De Luxe

By E. M. PAULLIN

Consulting Engineer,
Worthington Pump & Machinery Corp.,
Buffalo, N. Y.

OPERATING ECONOMY was attributed, in an earlier article[1] on the opposed type steam driven compressor, to the use of a balanced piston type of steam valve with an adjustable riding cutoff. The valve in reality is a double piston steam valve consisting of a main valve and an expansion valve. The latter is the riding cutoff type, and, being under control of the governor at all times provides for an early cutoff with high steam expansion. Since operating economy depends largely on this early cutoff it is reasonable to conclude that the accuracy of the initial valve setting as well as the use of a sensitive automatic cutoff governor are vital factors.

Assembly and markings at the factory permit field erection of the valve gear with only minor adjustments. Nevertheless, at some time during the life of the machine a dismantling of the steam end may necessitate resetting the steam valves so a knowledge of the proper procedure is indispensable to the engineer.

Figure 1, a sectional view of the steam chest, shows the essential parts, with the valves in mid-position, and important edges and point locations all lettered as follows: A, exhaust edge of valve bushing; E, steam edge of valve bushing; C, exhaust cutoff edge of main valve; D, steam edge of main valve; G, cutoff edge of main valve; F, cutoff edge of expansion valve; and B, outer face of steam chest.

Assembling the Valves

The main valve operates within the steam chest bushing and the expansion valve, consisting of two halves, rides within the main valve. Steam enters from the center and comes in contact with the outer edges of the steam chest only after expansion. For the purpose of explanation assume that we are making the initial valve setting.

Place the expansion valve halves on the expansion valve rod and locate them centrally with respect to the left hand and right hand threads. Fasten the nut on the head end of the rod and slide the assembly within the main valve shell. After this is accomplished the head end plate may be bolted on the main valve.

Expansion valve halves should now be shifted back and forth until the cutoff edges F and G come together at both the crank and head ends, the proper position for 50 per cent cutoff. It may be necessary to rotate the expansion valve rod to spread the expansion valves, or, bring them closer together as the case may be. A 0.005 in. feeler may be used to check this position. When the valves are in the proper position place a punch mark at X on top of the expansion valve rod as shown in the figure. The main piston valve rod should also be marked with a punch as shown at Y. Measure the distance between the marks X and Y with care and prepare a tram so that the valve rods may again easily be placed in this same position. Next, by rotating to the right, count the number of turns of the expansion valve rod required to bring the expansion valve halves together. Record the number of turns so that the halves may at any time be placed in the 50 per cent cutoff position and return the valves to their original positions, then check the measured distance X and Y with the tram.

On the main valve the distance between D and C

[1] See the article Opposed Type Steam Driven Compressors by E. M. Paullin, page 203 of the March, 1938, issue of Power Plant Engineering.

(which is the same at both ends) and the distance D to D should be measured and recorded. In the steam chest the distance from the face B to the steam edge of the valve bushing E at the head end, and, E at the crank end should be measured and recorded. The valve assembly may now be placed in the steam chest making certain that the ports are in line. The exact position of the various openings should now be determined by measuring the distance from C at the head end of the main valve to the steam chest face B.

Setting the Main Valve

Assume that the design of this particular engine requires a lead of 0.075 per cent, or an equivalent valve travel of 3/64 in. With the steam piston on head end dead center move the valve assembly in the direction of opening until edge D on the head end passes edge E by the distance of 3/64 in. Attach the main valve rod and adjust for approximate length, allowing eccentric to move on the shaft. When the approximate position is obtained, lock the eccentric on the shaft and roll the machine over in the proper direction of rotation until the steam piston is on crank end dead center.

With the machine in this position D, the steam edge of the main valve on the crank end, should have passed E, the steam edge of the valve bushing on the crank end, with the lead of 3/64 in. With the first attempt at adjustment a sizable error will exist. One-half of the error should be corrected by shortening or lengthening the valve rod. The second half should be made by moving the eccentric on the shaft, always in the direction of rotation. If it is found necessary to move in the reverse direction, move the eccentric a greater distance than is required and approach the exact point in the direction of rotation.

Again roll the machine over, in the direction of rotation, to head end dead center and check the position of the valve. With one or two adjustments at each end the proper steam admission points will be obtained and the main valve will be set. The eccentric may now be keyed to the shaft.

Setting the Expansion Valve

From this point on only one remaining adjustment, the length of the expansion valve rod motion, can be made, since the expansion valves are properly placed on the threaded rod and the position of the eccentric is fixed because the main valve eccentric and the expansion valve eccentric cams are machined in one piece. The proper length of the expansion valve motion is determined as follows.

Place a mark on the crosshead shoe and indicate on the guide barrel the extreme travel of this mark. Mark the guide barrel at exactly the mid point of travel and turn the compressor over in the direction of rotation until the two marks come together while the mark on the crosshead is approaching the mark on the guide while moving from the head end of the machine. If the rotation of the compressor is standard or commonly referred to as over[2] the crank pin will be on top and 50 per cent of the power stroke from the head end will be completed. For steam cutoff at this point (known as 50 per cent cutoff) the cutoff edges F and G on the head end must just come together. We are assured of this if the tram marks X and Y are the proper distance apart. The length of the expansion valve rod motion is adjusted until the proper distance is obtained. The position of the expansion valve halves on the valve rod may be checked, as explained before, by counting the number of turns required to bring the valves together.

Now roll the compressor over 180 deg. If the eccentric machining is perfect and all adjustments made properly the tram marks X and Y will again show their proper distance indicating that the cutoff edges F and G on the crank end have just come together. Actually, perfect adjustments are never obtained and the slight error should be divided by a further adjustment of the expansion valve rod motion so that the tram distance will fall an equal amount on each side of X as shown by the exaggerated positions C.E. and H.E.

Leaving the valves in this position means that at one end we might have a cutoff of 50.5, and at the other end 49.5 per cent. The difference is slight and does not affect the operation of the machine. When making

[2] Conventional designation of running "over" and "under" differs with the type of machine. With the machines under discussion, the proper direction of rotation, which is always indicated on the foundation plan, is "over" as defined in either of two ways: Standing between the steam cylinders and facing the flywheel, the top of the flywheel should turn away from you; standing at one side of the machine with the steam cylinders at the left, the flywheel should rotate clockwise.

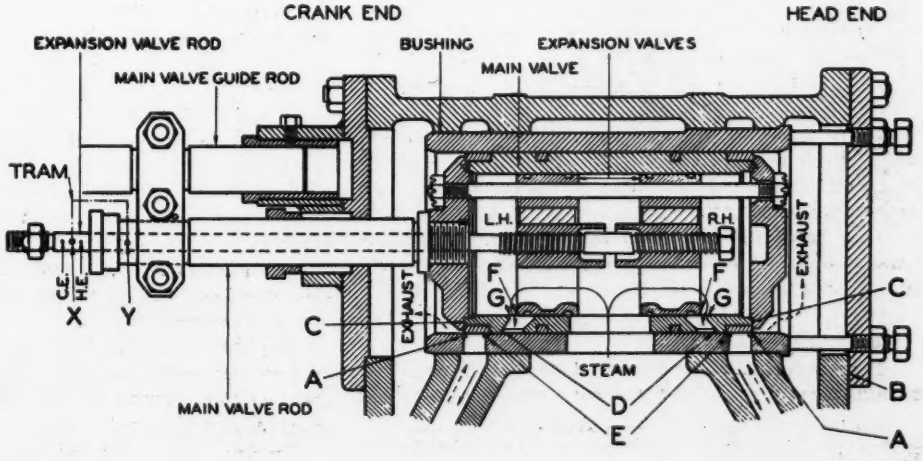


Fig. 1. Details of the steam chest and double ported valve with the parts identified so that the valve setting directions can easily be followed

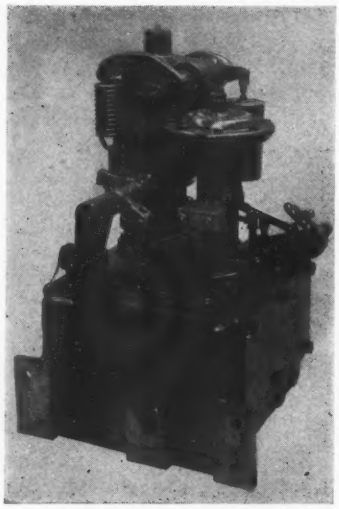


Fig. 2. View of the automatic cutoff governor shown diagrammatically by Fig. 3

adjustments in the field it is advisable to turn the machine over slowly several times to make certain that the valve motion is not binding and that there are no obstructions. After the machine is in service the final valve setting may be checked and often improved by comparing indicator cards.

Automatic Cutoff Governor

The main function of the governor is the control of compressor speed, that is keeping the machine at or below its rated r.p.m. The governor, however, must respond to changes in steam pressure and also maintain a constant pressure in the receiver as the demand for air or gas changes.

The governor affects its control by changing the steam cylinder cutoff. Lengthening the cutoff admits more steam during the power stroke, and shortening the cutoff will allow less steam to enter the cylinder for expansion or power purposes. As explained before, steam economy is obtained by operating with an early cutoff, and it is the function of the governor to admit just enough steam to perform the required work. Rotating the expansion valve rod will lengthen or shorten the cutoff and the governor actually turns this rod to the right or left.

The Worthington Class 30 automatic cutoff governor, shown diagrammatically in Fig. 3, includes essentially a servomotor with hydraulic transmission, a flyball speed element and a diaphragm pressure element. A chain from the compressor crankshaft provides a positive drive for the flyball speed element and the oil pump in the hydraulic transmission. The speed and pressure elements are required to operate only pilot valves and are, therefore, extremely sensitive.

Under normal operation, with a given steam pressure and spring setting let us assume we are operating at rated r.p.m. with a 50 per cent cutoff. If the steam pressure at the throttle is raised, the speed will increase and the flyball element overcoming the normal speed spring tension will open the lower and upper ports in the main pilot valve (shown by Fig. 3). This action will admit oil pressure to the left end of the servomotor, while relieving the oil pressure from the right end and so move the servomotor plunger to the right. Through the rack and pinion gear train the expansion valve rod will be turned to the left and shorten the cutoff.

A compensating linkage, operated from the cutoff position indicator, returns the pilot valve to the neutral position as soon as the cutoff has changed sufficiently to correct for the change in compressor speed. The diaphragm pressure element, reflecting changes in the air or gas pressure system, operates the pressure element pilot valve which, hydraulically through the reset piston, resets the normal speed spring. The tension in this spring will be decreased as the pressure on the pressure element increases. The flyball element will now respond to a lower speed setting and through the main pilot valve and the servomotor will alter the cutoff as required.

The governor may be quickly adjusted over a wide range for both speed and pressure. A minimum speed spring prevents the reduction of compressor speed to the stalling point and a separate overspeed trip protects the compressor against excessive speed.

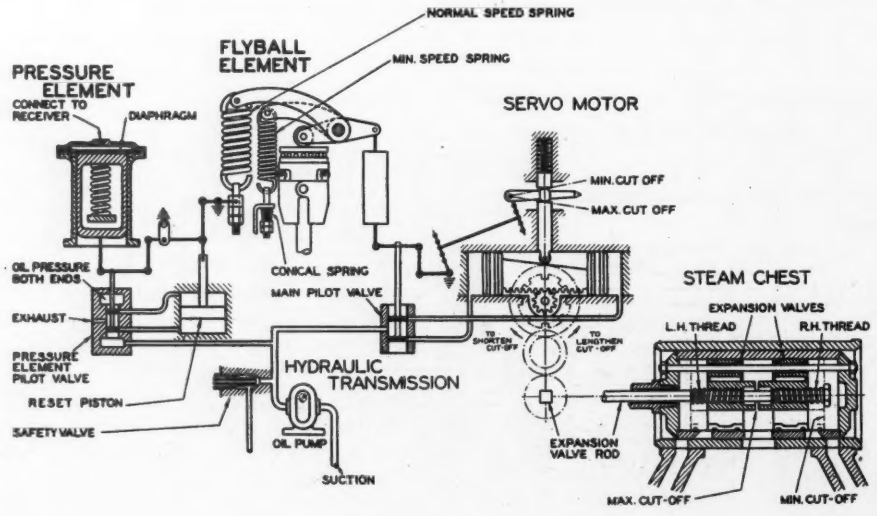


Fig. 3. Diagrammatic arrangement of the governor showing how the pressure element and flyball element actuate the pilot valve and servo-motor to change the cutoff in accordance with the load

In the process of boiling do you know why small bubbles rising from the bottom of a pan of boiling water disappear before they even reach the surface? In this second part of this article Mr. Stimson tells you why and follows it up with a mathematical consideration of the critical size of bubbles. Against the hard background of life, bubbles may be symbols of instability and indirection but in the process of evaporation they are factors of considerable importance.

Mechanism of Heat Transfer by Evaporation

By ALLEN G. STIMSON
Industrial Control Engineering Dept.
General Electric Company
Schenectady, N. Y.

IN PART I* of this article we discussed the fundamental mechanism of the process of evaporation from the standpoint of the molecular theory. The phenomena of surface tension and surface energy were studied and the effect of these concepts on surface metability and vapor bubble origination was examined in detail.

Now we will proceed at a consideration of the observations and theory incident to the superheating of a boiling liquid, the critical sizes of bubbles and drops, the heat transfer coefficient and the tangible factors which influence the coefficient.

*Page 498 August 1938 issue

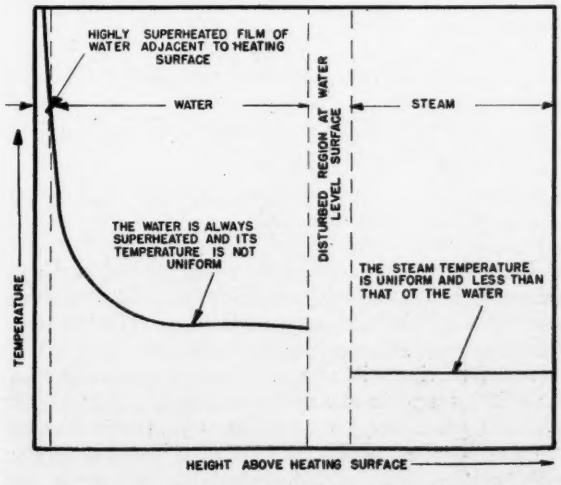

HIGHLY SUPERHEATED FILM OF WATER ADJACENT TO HEATING SURFACE
WATER
STEAM
DISTURBED REGION AT WATER LEVEL SURFACE
THE WATER IS ALWAYS SUPERHEATED AND ITS TEMPERATURE IS NOT UNIFORM
THE STEAM TEMPERATURE IS UNIFORM AND LESS THAN THAT OT THE WATER
TEMPERATURE
HEIGHT ABOVE HEATING SURFACE

Fig. 1. Temperature gradient above the heating surface in boiling water

Superheating of the Liquid

Henning observed in 1909 that the steam rising from boiling water was at a lower temperature than the liquid and Jakob proved that this difference did exist. In 1930 Bosnjakovic ([8]) published his theory showing how the superheating of water is essential to the mechanism of evaporation. In a series of tests Jakob observed the following degrees of superheat of boiling water:

Pressure Lb. per Sq. in.	Superheat °F
14.2	1.1
355.5	0.7
711.0	0.36
1066.5	0.18
1422.	0.09
2844.	0.0

It is natural to expect that the superheat would be zero at the critical pressure (3226 lb. per sq. in.) but the table indicates that the value approaches zero faster than the pressure approaches the critical.

The mean superheating of the liquid changes very little with the rate of evaporation. ([7])

A thin layer of liquid adjacent to the heating surface is highly superheated. A high temperature gradient exists in this layer starting with approximately the heating surface temperature and decreasing to the temperature of the main body of the liquid in a few

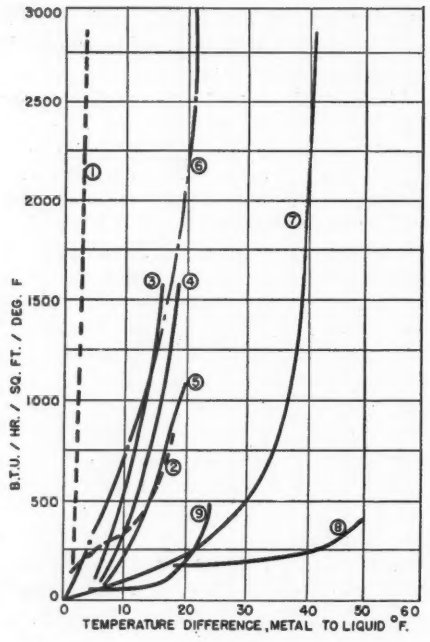


Fig. 2. Coefficients for evaporating liquids. (1), (2) Jakob and Fritz, water, 212 deg. F., horizontal copper plate, (1) grooved, (2) polished chromium surface. (3), (4), (5) Linden and Montillon, water, (3) 210 deg. F., (4) 195 deg. F., (5) 180 deg. F., inside inclined copper pipe, 1 in. by 4 ft. (6), (7), (8) Dunn and Vincent (6) water, 212 deg. F., (7) methyl alcohol 149 deg. F., (8) toluene, 232 deg. F., horizontal copper plate. (9) Young, methyl formate and ethyl ether, 60 deg. F., vertical copper plate

millimeters. This gradient depends on the rate of heat transfer and the temperature difference may be as high as 18 deg. F. (7)

This temperature drop also depends on the type of heating surface, being less for a rough surface than for a smooth surface because the former presents minute projections about which bubbles can originate at smaller radii of curvature.

In the case of the smooth surface the superheat is greater and the bubbles can originate at points on the heating surface having larger radii of curvature. Thus, the increase in superheat of the surface film tends to compensate for the effect of the smooth surface.

It has been observed that, even with a very smooth surface uniformly heated, bubbles may originate only on particular points of the surface, and that as the heating rate is increased the number of points of bubble formation also increase. This phenomenon can be explained on the basis that the increased heating rate increases the superheat of the surface film which permits bubbles to originate at portions of the surface having greater radii of curvature.

This discussion indicates that although the mean superheating of the liquid is little changed by increased rate of heat transfer, the superheat of the film on the heating surface does increase and is responsible for increased ebullition.

Across the water level surface the temperature changes from that of the superheated liquid to that of saturated steam at the existing pressure. This drop does not vary materially with the rate of heat transfer but is greater when the heating surface is smooth than when rough.

Under certain conditions the liquid may be superheated almost indefinitely without ebullition. Water has been superheated 180 deg. F when suspended in oil and ether has been superheated 117 deg. F. in a capillary tube.

It has been shown that superheating of the liquid is necessary to produce ebullition in a pure liquid. But it is also desirable that the necessary superheat be as low as possible. King (5) states that the tendency of a liquid to superheat is reduced by

1. The presence of dissolved gases or small particles in the water which form nuclei for the formation of the bubbles. Thus, bubbles can form in the body of the liquid at finite pressure.
2. Bubbling vapor or air through the liquid.
3. Localized hot spots such as small heating elements.
4. Raising the boiling point.
5. The presence of adsorbed air on the heating surface.
6. The presence of an ebullator in the liquid. Philipp and Tiffany found that by immersing various substances called "ebullators" in the liquid the superheat required for boiling was diminished. Fibrous wood was the best ebullator they found for sulphur dioxide.

The Critical Size of Bubbles

Small bubbles rising from the bottom of a pan of slowly boiling water have been observed to disappear before reaching the surface. The disappearance is attributed to the lower superheat of the upper layers of the liquid due to the cooling effect of surface evaporation so that the bubble can no longer be sustained. There seems to be a critical size of bubble for each degree of superheat; smaller bubbles are unable to withstand the surface tension and larger bubbles grow.†

The critical size of a bubble of pure vapor is given by equation (2) since with a given amount of superheat or excess pressure p, an increase in the bubble diameter D makes the bubble unstable and ebullition begins.

If a non-condensible gas is present in the bubble the critical size is reached when the partial pressure of the gas supplies one-third of that necessary to support the surface tension. The partial pressure of the gas in the bubble is then:

$$p_g = \frac{4\,S_t}{3D} \qquad (3)$$

Callender calculated that water would boil at atmospheric pressure at 100.05 deg. if the bubbles were 1 mm. in diameter and at 110 deg. C. if the bubbles were only .005 mm. in diameter.

From moving pictures of steam bubble formation Dr. Jakob found in one case that bubbles originate in the same place every 0.05 sec. and that each bubble adhered to the heating surface for 0.027 sec. The initial vertical velocity of the bubble was 17 cm. per sec.

†See part I, August issue, page 498.

and increased to 33 cm. per sec. as the bubble rose toward the liquid surface.

There is a maximum size which a bubble may attain before breaking away from the heating surface. W. Fritz has expressed this volume as a function of the contact angle

$$A = K \left(\frac{V}{a^3}\right)^{1/3}$$

where

A = contact angle or angle of capillarity
V = maximum volume of bubble
a = Laplace constant
K = a constant.

The Critical Size of Drops

The liquid in a drop of liquid is also at a higher pressure than the surrounding gas because of the surface tension and therefore, contains more energy than an equal amount of liquid in a main body of liquid. This excess or surface energy causes the drops to evaporate more readily than liquid in bulk.

Drops of liquid also have a critical size; those smaller than the critical evaporate while those larger than the critical grow in size. It is assumed, of course, that the drops are suspended in a supersaturated atmosphere. This critical size is expressed by the equation:

$$D = \frac{4\ S_t}{RT\ L_d \log_e P} \qquad (4)$$

where

S_t = surface tension
D = diameter of drop
R = gas constant
T = absolute temperature
L_d = density of liquid
P = the ratio of existing pressure of supersaturated atmosphere to saturation pressure at existing temperature.

A drop can be in equilibrium only with a supersaturated vapor.

For a drop of water at 10 deg. C. where P = 1.05 the critical diameter is .0001 mm.

The Heat Transfer Coefficient

In the design of evaporators it is necessary to predict within reasonable limits of accuracy the amount of heat that can be transferred from a solid surface at a given temperature to a liquid boiling on that surface at a definite temperature or pressure. For this purpose empirical data have been obtained through arduous work by many experimenters. These data have been correlated in terms of a unit known as the "heat transfer coefficient" which has been denoted by the letter "h". This coefficient is usually expressed in units of B.t.u. per hr. per sq. ft. per deg. F. and represents the unit flow of heat in B.t.u. per hr., from the heating surface to the liquid and which escapes therefrom in the latent heat of the vapor. The rate is based on the temperature difference between the heating surface and the vapor.

Factors Influencing the Coefficient

King ([5]) gives ten factors which influence the heat transfer coefficient.

1. The coefficient increases very rapidly with the temperature difference. The value of the exponent n in $h = \theta^n$ usually lies between 2 and 3. (θ represents the temperature difference. This increase is attributed to the increased agitation resulting from more vigorous ebullition.)
2. At high heating rates, the coefficient increases almost linearly with the heating rate.
3. At very high heating rates, a continuous film of vapor may form at the heating surface, separating it from the liquid and causing the surface temperature to rise sharply. (Note that this phenomenon may occur at moderate temperatures if the pressure is low.)
4. Ebullition may occur vigorously at certain points which are colder than adjacent points where no bubbles appear.
5. In several tests at moderately high heating rates it was found that the introduction of devices for promoting or retarding the circulation as much as possible had no effect upon the coefficient.
6. Circulation and ebullition may be very unstable, particularly at moderate heating rates.
7. Even with a heavy copper plate, uniformly heated, marked differences in metal temperatures may be found at various points on the surface.
8. Much more consistent results are obtained with perfectly clean surfaces.
9. The coefficient may gradually decrease with the duration of the heating time, apparently due to the removal of dissolved and adsorbed air. Jakob and Fritz ([2]) found that the coefficient for water decreased as much as 60 per cent after it had boiled for 12 hours, but increased again after the heating surface was allowed to stand a while in air.
10. Regular, periodic variations in temperatures and evaporating rates may occur. This is apparently due to the periodic superheating of the liquid in the film up to the point where the vapor pressure overcomes the internal tension.

Claassen ([6]) pointed out in 1902 that if the bubbles could be readily removed from the heating surface more of the area would be available for new bubbles to form. Hence, the coefficient should increase with the velocity of the liquid over the surface. This conclusion has been verified by test and it has become the usual practice to run the water through boiler tubes at relatively high velocity. Stirring of the boiling liquid produces the same result.

Claassen also pointed out that the over-all coefficient from condensing steam to boiling liquids increases with increase in temperature of the liquid and with decrease in concentration of aqueous solutions.

Tests of Linden and Montillon show that with a temperature difference of 15 deg. F. the coefficient for water boiling at 180 deg. F. was 500 whereas when boiling at 210 deg. F. the coefficient was 1800. Badger and Shepard obtained similar results.

Jakob and Fritz showed that a rough surface was better than a smooth surface. They showed that a grooved surface was better than a sand blasted surface although either was better than a polished chromium plated surface. The rough surface evidently provides increased area for bubble formation and consequently a larger number of vaporization nuclei. Also, the minute projections on a rough surface allow bubbles to originate at smaller radii. A screen surface was found to be the best of any tested.

However, it is more important that a surface be clean than that it be rough. The effect of dirt on the surface may more than offset the effect of surface roughness.

The effect of scale on the heating surface has been shown by Pridgeon and Badger to have the following effect ([3]) on the over-all heat transfer coefficient from condensing steam (source of heat) to boiling water. The temperature difference was 36 deg. F.

	B.t.u./hr. sq. ft. deg. F.
Rusty iron	324
Clean iron	460
Slightly dirty copper	950
Polished copper	1470

The depth of the liquid over the heating surface also affects the coefficient. It is found ([3]) that h increases with the depth up to a certain point probably due to increased wetting of the surface. The decrease of h with further increase in the depth of liquid is attributed partly to the change in temperature difference caused by the hydrostatic head and partly to a change in circulation. From three to twenty inches seems to be the optimum hydrostatic head for water.

Attempts have been made to correlate the value of h with the physical properties of the liquid. The formula of Cryder and Gilliland is probably the most fruitful equation available.

$$h = \frac{0.0617\ \theta^{2.4} K^{1.8}\ C^{0.4}\ S^{2.4}}{Z^{3.2}}$$

where

θ = temperature difference—deg. F.
K = thermal conductivity of the liquid in B.t.u./hr. sq. ft. deg. F./inch
C = Specific heat—B.t.u./lb. deg. F.
S = Specific gravity
Z = Viscosity in centipoises.

This formula is based on tests of eleven different liquids boiling at atmospheric pressure and heated by a horizontal brass cylinder of one inch diameter.

The equation is of less use for determining the coefficient than for predicting the effect of fluid properties.

Values of the Coefficient of Heat Transfer

Since the various factors outlined above have a marked effect upon the value of h and since some of these are inherent in a given design of evaporator, the performance cannot always be predicted accurately but the results of calculations do provide a sound basis for design.

The chart ([5]) Fig. 2 gives some representative values of the heat transfer coefficient. Values of h for many different liquids under various conditions may be found in McAdam's text ([3]) and in King's paper ([5]).

References

1. A. W. Duff, "Physics" P. Blakiston's Son & Co. (1926).
2. Jakob & Fritz, Forsch.—Gebiete Ingenieurw Vol. 2, p. 434 (1931).
3. McAdams, "Heat Transmission" McGraw-Hill (1933).
4. Dupré, "Theorie Mecanique de la Chaleur" 369 (1869).
5. W. J. King, "Heat Transmission," Mech. Eng., Aug. 1932.
6. Claassen, "Mitt Forschungsarb," V. 4, p. 49 (1902).
7. Max Jakob, "Heat Transfer in Evaporation and Condensation, Mech. Eng., Oct., 1936.
8. F. Bosnjakovic, Technische Mechanik und Thermodynamik, Vol. 1, p. 358, 1930.

Capacitors to the Rescue

Well-planned capacitor installations on feeders serving the downtown area of Warren, Ohio, recently solved the problem of how to handle power consumption increase for the Ohio Public Service Company. The installation has precluded the necessity of expanding existing facilities and is realizing appreciable operating economies.

The complete program calls for the installation of 1800 kv-a. of capacitors within 4 yr. 360 kv-a. of these units have already been put in, effecting an initial saving of $6500 on forestalled substation investment.

The installation was made after a study of the factors involved had been conducted jointly by General Electric and Ohio Public Service engineers.

The study revealed that the location and physical layout of the existing substation would not permit the addition of new capacity. To expand facilities would have required building a new substation far on the other side of town—the only place where a suitable site was obtainable.

Further conservative analysis disclosed that an installation of 420 kv-a. of capacitors at a cost of approximately $4000 would release 230 kv-a. of the present substation capacity, permitting profitable handling of the anticipated load growth for one year.

By extending the program over a four-year period until a total of approximately 1800 kv-a. of capacitors have been installed, estimated yearly load increases on the substation will be relieved, according to the program analysis.

The survey showed that the following annual savings might be claimed in addition to the $6500 saving on forestalled substation investment:

Value of released generating capacity	$23,600
Value of released feeder capacity	5100
Increased revenue	3500
Savings in distribution feeder copper losses	3000

Power Interchange

John Morrell & Co., meat packers, installs a new back pressure turbine and completes an interesting power interchange agreement with the local utility

By B. WINGER

Chief Engineer,
John Morrell & Co.,
Ottumwa, Ia.

PRIVATE GENERATION of industrial electric power vs. purchase of power from a utility is always controversial so the solution worked out by John Morrell & Co. of Ottumwa, Ia., is particularly interesting. Within the last year this company has completed the installation of a new turbine generator and has effected an agreement with the local utility company to allow this generator to float on the utility lines and to supply standby service on a reciprocal basis. Thus power generated in excess of plant needs, by reason of plant steam requirements, flows over to the utility company while Morrell requirements in excess of power generated is automatically supplied by the utility company.

Figure 1 shows the operation of the new turbine generator for a typical period. The upper curves show the output record of the generator and the power consumption of the plant with power bought from, and sold to, the utility indicated by crosshatched and mottled areas. The lower curves show the steam requirements for the various pressure systems shown diagrammatically by Fig. 2.

The new turbo-generator unit, rated at 2000 kw., 2400 v., 3 ph., 60 cycle operates at throttle conditions of 410 lb., 700 deg. F. and the generator is in parallel with the utility system. The turbine is bled at 150 lb. and discharges at 65 lb. for plant use. Steam at the higher pressure is used for driving ammonia compressors, pumps, etc., while the lower pressure is used in processing operations. Several pieces of equipment, such as the compressors and pumps, exhaust at 5 lb. pressure to supply the heating and a low-pressure steam processing system. A battery of reducing valves with desuperheaters, adjusted to deliver steam to the lower pressure equipment with a slight superheat, works in parallel with the turbine when steam requirements exceed the capacity of the turbine, or when the turbine is down.

High pressure steam is supplied by a boiler, which although installed in 1935 and operating at 165 lb., was designed with power generation in mind, for, Morrell engineers[1] have been studying plant processing requirements for a number of years to determine the

[1] Dan S. Helmick of Helmick, Edeskuty & Lutz, Minneapolis, Minn., was consulting engineer.

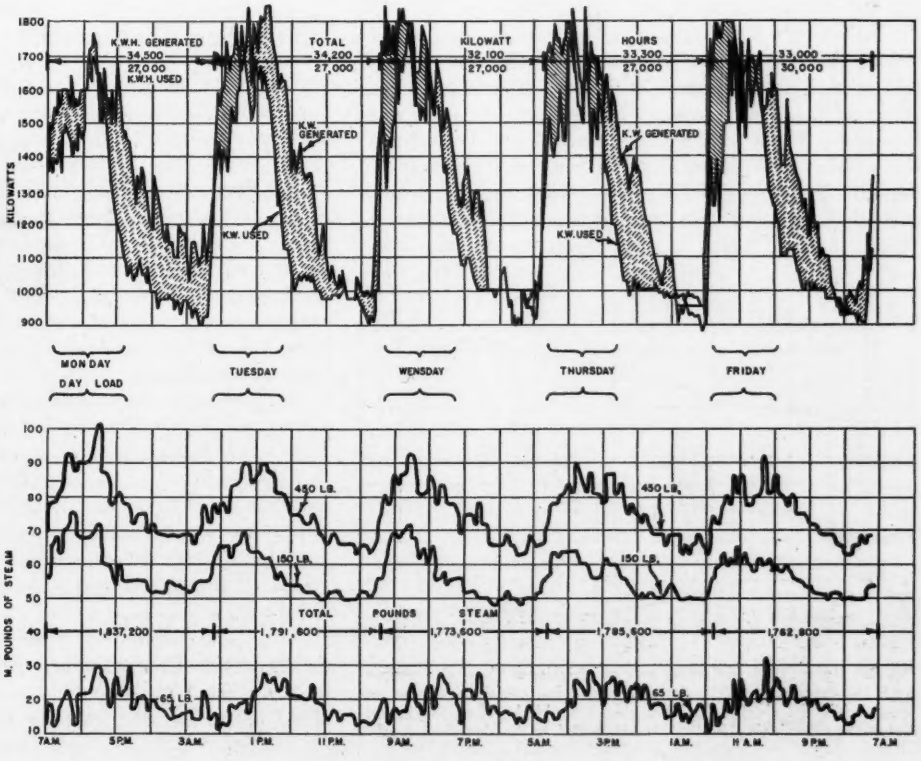
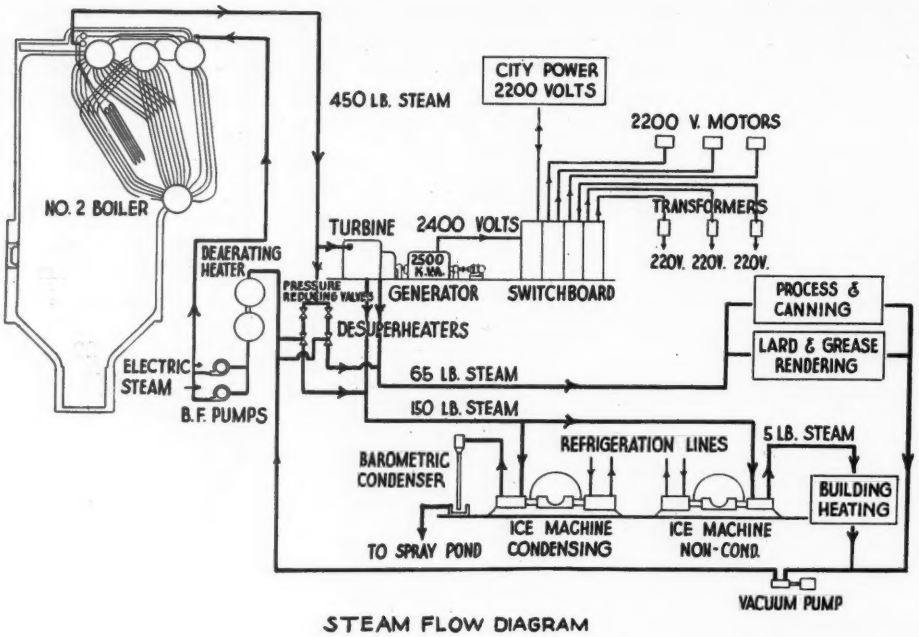


Fig. 1. Typical steam and electric load curves from Monday to Saturday morning. An average of approximately 6000 kw-hr. per day is generated in excess of electric power needs and this is sold to the utility during the night. During the day power is usually purchased as shown by the crosshatched areas, and, during the night is sold, as shown by the dotted areas. The new turbine is a 2000 kw., 2400 v. unit operating at throttle conditions of 410 lb., 700 deg. F. with extraction at 150 lb. for supplying compressors and pumps and exhausting at 65 lb. for process. Some of the compressors and pumps exhaust at 5 lb. to supply the heating and low pressure process system



STEAM FLOW DIAGRAM

Fig. 2. Four steam pressures are used as shown by this flow diagram and the generator operates in parallel with the utility system on a power interchange basis

feasability of generating power with bleeder type turbines. The boiler with a normal capacity of 100,000, or a peak capacity of 120,000 lb. per hr. at 450 lb., 700 deg. F., includes air heaters, forced and induced draft fans, dust collectors and a completely water cooled furnace.

Pulverized coal is used as fuel primarily because Ottumwa is located in the Iowa coal fields and Iowa coal has been successfully burned in the plant in pulverized form since 1930 when a 90,000 lb. per hr., 200 lb. boiler was installed. The coal averages approximately 9000 B.t.u. per lb. with about 15 per cent ash and as high as 18 per cent moisture. Previous to 1930 chain grates had been used in the plant, but, the success of the Morrell plant at Sioux Falls, S. Dak., burning southern Illinois coal in pulverized form, was the deciding factor in the change which proved so successful that it was also used in the boiler installed in 1935.

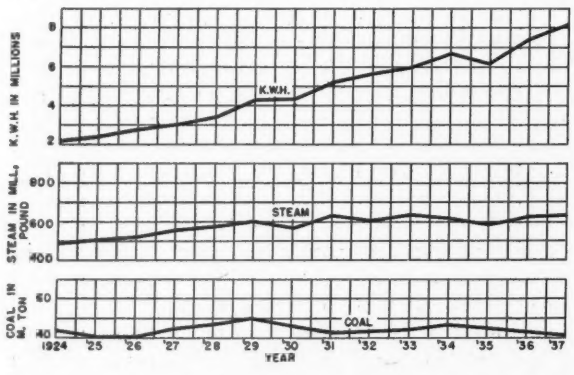


Fig. 3. Up to 1929 the steam and electric loads showed a proportional increase. Since 1929 the steam load has remained almost stationary while the electric load has almost doubled. The drop in coal consumption beginning in 1935 is attributed to the installation of a new boiler

This is not the first venture of this plant into power generation for a 125 lb. vertical condensing turbine unit was installed as early as 1905. Eventually, as the equipment became obsolete and the load increased, arrangements were made to obtain power from the local utility but steam for plant uses, for ammonia refrigeration compressors and for pumps continued to be supplied from the plant boilers.

Lubricating Oil Viscosity

VISCOSITY of lubricating oil is a matter of some importance in oil specifications, although the part it plays and its effect are not as yet thoroughly understood. This was discussed at considerable length by S. W. Sparrow of The Studebaker Corp. before the S. A. E. Summer Meeting, largely from the standpoint of information accumulated as a by-product of routine engine tests and development.

Among other things he discussed the effect of viscosity on blowby in automotive engines. In one engine the substitution of No. 40 for No. 20 S.A.E. oil reduced the blowby from 1.7 cu. ft. per min. to 0.5 cu. ft. per min. In another engine operating at 4500 r.p.m., the blowby was as follows: S.A.E. 40 oil, 3.2 c.f.m.; S.A.E. 30 oil, 3.9 c.f.m.; S.A.E 20 oil, 4.4 c.f.m.; S.A.E. 10 oil, 6.6 c.f.m. In case the ring combination is ineffective, the viscosity effect may be even more apparent. In one such engine operating at 4500 r.p.m., the blowby was increased from about 3.6 to about 7 c.f.m. when the oil was changed from S.A.E. 40 to S.A.E. 20.

EXPERIMENTAL 15 watt green fluorescent lamps have operated at 70 lumens per watt compared with about 0.3 lumen per watt for 60 watt filament lamps, an efficiency gain of about two hundred fold.

Part II. Structural stability, service, long and short time tests from the standpoint of creep predictions. Importance of service factors in the design of power plant piping systems. Corrosion and oxidation resistance as affecting service life. Effect of carbon chromium, molybdenum and silicon. Weldability of different alloys, preheating and stress relieving. Cost factor as influenced by temperature and pressure. Possibility of 1000-1100 deg. F. temperature in the near future

By

SABIN CROCKER,
Senior Engineer, Engineering Div.
and
HARVEY A. WAGNER,
Engineer, The Detroit Edison Co., Detroit, Mich.

Limiting Factors for High Steam Temperatures

AMONG the peculiarities of a steel which may influence its high-temperature load-carrying ability are chemical composition, uniformity of structure, heat treatment, grain size, previous deformation, structural stability, and method of manufacture which embraces distinctions such as open hearth or electric furnace, killed or open, normal or abnormal, etc. Only recently has it been sensed that so many characteristics of a steel enter into its creep behavior; undoubtedly there are others having more or less effect as yet undetermined. Hence it is not surprising that metallurgists cannot predict the behavior of metals at high temperatures so well as has been done at temperatures where creep is not a factor.

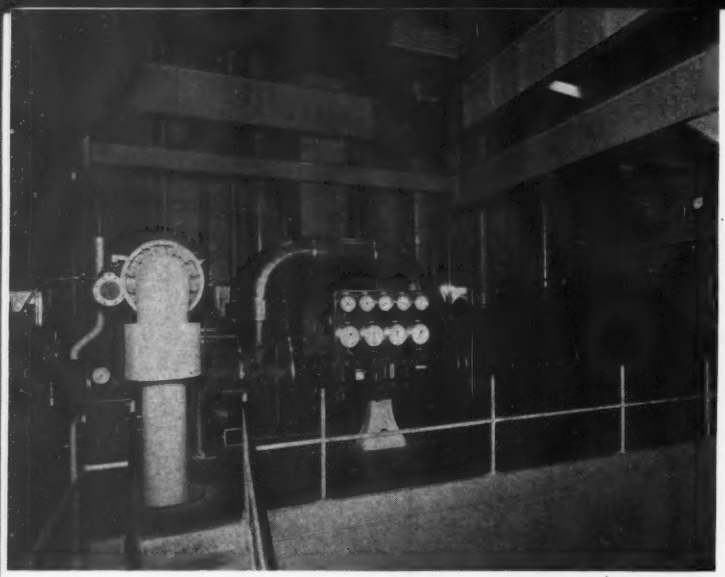
Structural stability at elevated temperatures is an important item. Even at temperaures as low as 1000 deg. F. in the presence of stress, carbon steel has been shown to possess a definite tendency to slowly change its structural formation from pearlitic to a spheroidized structure. At temperatures of 1200 to 1300 deg. F., the change proceeds more rapidly and may be completed in a period of a few hours. In the spheroidized condition, creep resistance may be reduced considerably below that obtained in the pearlitic state. However, some recent results with carbon-molybdenum steels have indicated that when partly spheroidized, carbon-moly steel may possess better creep resistance than it does in either the original pearlitic condition, or the more fully spheroidized state.[1]

In any case, it is considered desirable from the standpoint of predicting the useful life of the material to secure by heat treatment the most stable structure, and use the alloy at a temperature below which any active change of structure is encountered. Several of the ASTM specifications for high-temperature piping materials specify that in heat treatment of ferritic steels, the material shall be drawn at a temperature from 125 to 200 F. higher than the service temperature in an effort to secure a stable structure which will resist pronounced change at the service temperature.

Greater latitude in structural changes may be permitted in some cases, such as in the oil industry where material is used at a somewhat higher temperature than would be considered desirable in the power industry, on the supposition that when the material has reached the limit of its usefulness, it will be replaced. Since in the oil industry, frequent disassembly and inspection of piping is the rule rather than the exception, replacement of such material is readily effected.

Another property closely related to structural stability is toughness, or absence of brittleness, at room temperature after prolonged heating at high temperatures. Addition of molybdenum, tungsten, titanium, or columbium to some steels has a beneficial effect in reducing the tendency toward embrittlement after

[1]Influence of Heat Treatment on Creep of Carbon-molybdenum and Chromium-molybdenum-silicon Steel by R. F. Miller, R. F. Campbell, R. H. Aborn, and E. C. Wright, Transactions of the ASM, March, 1938.



High temperature turbine, a 10,000 kw., 1000 deg. F. unit in service at Delray from 1930 to 1937

service, particularly the 5 per cent chrome steels which without the additional alloying elements have been found to exhibit this tendency to a marked extent. Embrittlement after service generally has no observable effect on the microstructure.

A short length of 5 per cent chrome pipe with tungsten addition was inserted in the 1100 deg. F. experimental steam pipe line at the Trenton Channel Plant of the Detroit Edison Company to determine its suitability for steam service at 1100 deg. F. Samples taken from the tubing as received and after 18,000 hr. of service at 1100 deg. F. indicate that no great changes had occurred during service and that no particular embrittlement was experienced. Results are shown in Table VI.[2]

Similar tests on 18-8 after 36,000 hr. service at 1100 deg. F. indicated some embrittlement, although the physical properties were still good as shown in Table VII.

On the other hand, plain carbon steel held at 1000 deg. F. for a prolonged period has been shown to possess a very marked decrease in elongation and reduction of area on tensile test at 1000 deg. F. temperature.[3] The toughness may be materially decreased to such an extent that failure under pressure might occur without the usual warning "bulge" exhibited by a ductile steel. This is, of course, an undesirable condition which is one of the pertinent limiting factors in the high-temperature use of carbon steel. In contrast to the carbon steel, a low-chrome-silicon steel operating at 1100 deg. F. at a reasonably high stress has exhibited a very definite "bulge," and therefore was removed before failure took place. The magnitude of the stress in the material, the length of time for rupture, and the metallurgical condition of the steel prior to use have been demonstrated to be important factors which may greatly influence this type of failure. In the case of 18-8 material not stabilized by titanium or columbium, or by suitable heat treatment, intergranular corrosion may reduce the ductility and impact strength to a marked extent. This is particularly applicable in the case of welds where the

[2]Pipe, Valves, and Turbines for igh Temperature Steam, by R. M. Van Duzer, Jr., Metal Progress, June, 1937.

[3]"Creep Characteristics of Metals," by C. L. Clark and and A. E. White, Transactions of the ASM, December, 1936.

welding destroys previous heat treatment. Since the changes in structure at or near the grain boundaries result in intergranular oxidation or corrosion, the latter are often considered under the classification of structural stability rather than corrosion as customarily thought of.

As investigation is directed to the individual factors mentioned above as influencing the creep strength, each in turn is apt to be given the role of being the most important. At the present time, heat treatment and grain size are under careful examination to determine to what extent creep performance can be predicted and influenced by rigorous control of these features.

Thus far no short time tests of a few days or less have been devised which give satisfactory assurance that long-time load-carrying ability can be successfully prophesied thereby. In fact, many of the results so far secured from long time creep tests carefully conducted in accordance with ASTM requirements have been so discordant that logical interpretation into terms of allowable stresses has been extremely difficult, if not impossible. It is hoped that interpretation of the results eventually will be facilitated through a better knowledge of the inter-relation of the several factors which affect the creep strength and the result of various combinations of these several factors which are being investigated. In considering the present unsatisfactory state of knowledge regarding the peculiarities and characteristics of the phenomena called creep, it should be borne in mind that engineers and metallurgists have been creep conscious for only a matter of 12 to 15 yr. at most, while extensive investigation of creep at elevated temperatures has been under way for only about 10 yr. Hence there has not

Table VI. Service test, after 18,000 hr. at 1100 deg. F., of 5 per cent chrome tubing with a chemical analysis of carbon: 0.11 per cent; chromium 5.0 per cent; and, tungsten 0.96 per cent. Compare the changes with that of plain 18—8 tubing in Table VII

Property	Before Service	After Service
Tensile Strength, lb. per sq. in.	77,800	74,900
Yield point, lb. per sq. in.	42,800	41,000
Elongation in 1 in., per cent	34	34
Reduction of area, per cent	71	71
Izod impact, ft. lb.	39	34
Hardness, Rockwell B	80	77.5

been sufficient time to acquire that background of data and experience needed to reconcile a multitude of observations which to first appearances seem rather conflicting or discordant.

In the meantime, selection of materials from the viewpoint of long-time strength and corresponding allowable stresses for use in the design of piping for new power plants has been left pretty much to the judgment of individual designing engineers supplemented by the meagre creep data available.

Corrosion and oxidation resistance of steels is proportionate to the temperature at which they are used and therefore the ability to withstand the decrease in wall thickness resulting therefrom is important as it affects the service life of the alloy. This property of the steel may be equally or more important than high-temperature strength in limiting its usefulness.

CORROSION: Laboratory data heretofore available on corrosion of steel has been of little value due to failure to stimulate actual service conditions. Tests should be conducted on an experimental scale in an actual installation, or laboratory tests devised which will approximate commercial installations. Corrosion tests are being conducted in the laboratory at Purdue University[4] under conditions simulating those in the field and other tests are being conducted independently by the Detroit Edison Co. in their 1100 deg. F. experimental superheater piping at the Trenton Channel Power Plant. Little data is available as yet from either source.

In general, however, it is concluded from information obtained in steam and oil service so far that an increase in carbon content increases the corrosion rate, addition of chromium up to a certain maximum some-

Table VII. Service tests of low carbon 18—8 tubing after 36,000 hr. 1100 deg. F.

Property	Before Service	After Service
Tensile Strength, lb. per sq. in.	91,600	115,000
Yield Point, lb. per sq. in.	37,800	57,200
Elongation, per cent	53	37
Brinell Hardness	143	183
Izod Impact at 70 F.	68	29

where between 1 and 3 per cent has a very beneficial effect in decreasing the corrosion, and molybdenum does not significantly affect the corrosion rate in low alloy steels. If anything, the rate is greater for carbon-molybdenum steels than for a plain carbon steel of similar composition. Still higher percentages of chromium, particularly with the addition of molybdenum as in the 5 per cent chrome steels and the 18 chrome, 8 per cent nickel steels offer greatly increased resistance to corrosion, especially at the higher temperatures where the low alloys would be of doubtful value on account of their susceptibility to corrosion by steam.

OXIDATION: Oxidation resistance of a material is measured in the laboratory by the weight loss after heating specimens in air for a prolonged period. Data thus secured is of significance in considering the degree of scaling due to oxidation of a pipe carrying steam at high temperatures. A pipe carrying steam at 1000 deg. F., for instance, is visibly red in a fairly dark room and while the pipe is not directly exposed to the air, the pipe insulation is by no means air tight, and so, permits exterior scaling.

Chromium has the same beneficial effect regarding oxidation resistance as is the case for corrosion resistance except that larger percentages are required to be effective. While chromium additions up to 3 per cent somewhat increase scale resistance, an addition of 4 to 6 per cent produces a very definite benefit. Silicon, contrary to first impressions, has been shown to be of little assistance in oxidation resistance. The 18-8 material is non-scaling at temperatures up to 1000 deg. F., and only very slightly scale forming at 1250 deg. F. The comparative oxidation resistance at 1000 deg. F. of the four steels mentioned herein is reported as follows in loss in weight in grams per sq. in. of original surface:[6] 18-8, 0.00; 5 per cent Cr—½ per cent Mo, 0.03; C-Mo. 0.06; Carbon, 0.06. It may be observed in the case of oxidation resistance as well as corrosion resistance that the addition of molybdenum to plain carbon steel has no beneficial effect.

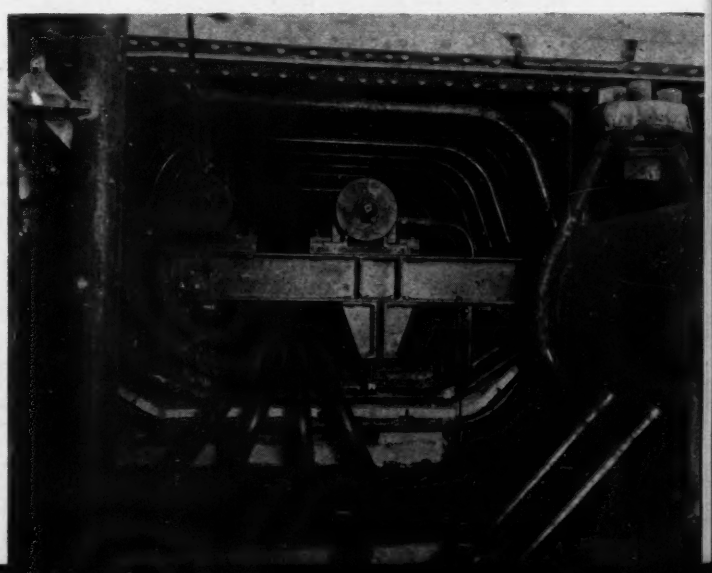
Welding of power-plant piping received a signal impetus through the increasing severity of service conditions in power plants where difficulties in securing and maintaining tight bolted joints led to the development of welding as a means of eliminating flanged connections. The adoption of welding entailed considerable effort in perfecting the process to a satisfactory state, checking the competence of welding operators before qualifying them for the job, controlling the uniformity of their work, and stress relieving joints after completion of welding.

There also was involved the problem of securing pipe and casting alloys which are easily weldable without excessive air hardening tendencies. The question of being easily weldable is stressed since by using proper technique, practically any alloy can be welded, but the more highly alloyed steels sometimes require definite and elaborate precautions which render them unfit for use on a commercial basis.

Ordinary grades of medium-carbon steels with a maximum carbon content of about 0.30 per cent and a manganese content of about 0.70 per cent are considered easily weldable. Reduction of the carbon content below 0.30 per cent is considered to warrant a corresponding increase in the manganese content up to a maximum of about 1 per cent. No preheating of the metal is required and while stress relieving often is employed to make certain that the joint is in the best possible condition as regards locked-up stresses due to welding, it is not indispensable except on heavy walled pipe. Thus while plain carbon steel is limited in other respects in its use for power-plant piping, it has a definite advantage over other steels in its easy weldability.

[4]"Investigation of the Oxidation of Metals by High-Temperature Steam" by A. A. Potter, H. L. Solberg, and G. A. Hawkins. ASME Transactions, RP-59-10, 1937.

[6]Digest of Steels for High Temperature Service, Timken Steel and Tube Company.



No. 8 boiler at Delray No. 3 showing the superheater headers and shop weld from carbon-moly nipple to 5 per cent chrome tubes and field weld from nipple to carbon-moly stub which is in turn welded to the outlet header

Carbon-molybdenum steel of the ½ per cent molybdenum variety is probably the most easily weldable of the alloy steels. To avoid air hardening of the fused material, however, it is considered desirable to preheat the joint to 300 to 400 deg. F. prior to, and during, the welding operation. Where preheating is not employed, there is said to be a tendency to form fine cracks in the weld metal before it can be stress relieved, particularly in the weld layers first deposited since the chilling effect is more severe at the outset of welding. This tendency is thought to be more pronounced where the carbon content exceeds 0.20 per cent. Stress relieving is considered imperative for welded carbon-molybdenum joints, although preheating somewhat lessens the necessity for so doing. The superior load carrying ability of carbon-molybdenum steel and its suitability for use at temperatures up to 950 deg. F. as compared to carbon steel may be considered to be obtained at the expense, for one thing, of the greater difficulty in welding involving both preheating and stress relieving, a more costly procedure.

Five per cent chrome alloy is weldable, but could not be classed as being easily welded. Special technique involving preheating, careful cooling, stress relieving, and careful control during welding make it a difficult alloy to weld successfully without excessive air hardening and resulting cracks in the weld metal. The eighteen and eight material also requires careful procedure control to secure satisfactory welds having the same degree of corrosion resistance as the parent metal. From the standpoint of weldability, both of these alloys are considered among the more difficult to weld satisfactorily, which is a definite deterrent in their use.

Cost

For high temperature service, the final but by no means least important element is the cost of piping as represented by the materials cost, welding cost, and some indirect items such as cost of pipe fabrication, provision for flexibility, hangers, anchors, etc. The decreased plant heat rate and consequent savings in cost of power production secured through higher steam temperatures must more than offset the increased fixed charges resulting from higher capital expenditures including piping as reflected by the foregoing items. Otherwise there is no economical justification for raising the steam temperature, and taking chances with unforeseen operating troubles induced by the higher temperatures.

To illustrate the inter-relation of some of the foregoing items, Table VIII has been prepared to show the cost of a 24 ft. length of 8 in. pipe made of the four materials considered herein, assuming the operating service conditions were 600 lb. per sq. in. at 850 deg. F., and 1200 lb. per sq. in., at 950 deg. F. The comparison can be considered as affecting only one item in the total installed cost of piping, since the material cost for pipe alone constitutes merely a portion of the entire installation and neglects cost of fabrication, erection, welding, material cost for valves and fittings, etc., all of which will add up to many times the material cost for pipe. Further, 5 per cent chrome and 18-8 pipes are not available in wall thicknesses heavier than 0.322 in. so the costs of pipe assigned in the table were extrapolated on the basis of the cost per pound of 0.322 in. wall pipe from a recent quotation. This is also true for the heavier carbon and carbon-molybdenum pipe.

Allowable stresses given in Fig. 1[7] were used in arriving at the wall thicknesses. Standard thicknesses in accordince with the schedules of ASA Standard B36.10-1935 were used for carbon and carbon-molybdenum steels where available, and the corrosion allowance for plain-end pipe prescribed by the ASA Code for Pressure Piping was included also for carbon and carbon-molybdenum steels. Computed thicknesses were used for the 5 per cent chrome and 18-8 alloys without addition of a corrosion allowance, but including the customary mill tolerance of 12.5 per cent.

Table VIII. Comparative cost of 24 ft. lengths of 8 in. pipe for carbon and alloy steels. Up to about 850 deg. F. carbon steel is the most economical. Around 950 deg. F. and for higher pressures carbon-moly pipe is less expensive

	Killed Carbon	Carbon-Moly	5% Chrome	18-8
FOR 600 POUNDS PER SQUARE INCH, 850 DEG. F.				
Wall Thickness, in.	0.500	0.406	0.231	0.174
Cost	$41.00	$88.00	$108.00	$279.00
Ratio to Carbon Steel	1.00	2.15	2.64	6.80
FOR 1200 POUNDS PER SQUARE INCH, 950 DEG. F.				
Wall Thickness, in.	2.000*	0.812	0.635	0.458
Cost	$176.00	$167.00	$318.00	$770.00
Ratio to Carbon Steel	1.00	0.95	1.81	4.38

*10 in. pipe assumed to provide approximately the same inside diameter as for 8 in. alloy pipe. Increased cost of insulation and the larger size valves and fittings required for this size will increase the cost differential in favor of alloy pipe.

The cost comparison indicates that at temperatures up to 850 deg. F., carbon steel is the most economical material to use on the basis of present cost data. For temperatures of around 950 deg. F., however, carbon-molybdenum alloy steel is shown to be the less expensive. Since the heavy walls of carbon-steel pipe materially reduce the carrying capacity in comparison to that of the alloy pipe, a 10-in. carbon-steel pipe is compared to an 8-in. alloy pipe for the 1200 lb. condition. The inside diameter of the 10-in. carbon-steel pipe is 6.75 in. as compared to 7.00 in. for the carbon-molybdenum, which is favorable to the alloy pipe from a pressure drop standpoint. Cost of fabrication, cost of valves and fittings, welding, insulation, provision for adequate expansion, etc., for the larger and heavier carbon steel pipe would considerably increase the cost in using carbon steel compared to alloy steel, even were it otherwise suitable.

Conclusion

In any decision involving selection of piping materials for high-temperature service, it is obvious that strength, corrosion and oxidation resistance, weldability, and cost must each be given due consideration. From the discussion of these items contained herein, an indication may be obtained as to why the maximum temperature of 950 deg. F. is now adhered to in building power plants. Within the next few years, new materials, new knowledge of metallurgical control, different welding procedures, and new cost alignments probably will render this pattern entirely obsolete. Temperatures of 1000 to 1100 deg. F. or higher may then be the rule rather than the exception in the power industry.

[7]Used in Part I, see page 490 of the August 1938 issue.

The Early History of Steam Generation

She makes me look into a glass ball

Dear Ed:—

I see by your last issue that this here Pulverizer Pete is back again with how to erect boilers. If the fellers what reads your magazine reaaly wants to find out about this business, they should take my advice and go down to the corner newsstand and buy the latest "Hollywood Thrilling Romances", from which they can learn more about boiler erection than this guy ever knew. If I ever lay my hands on that guy, they will have to change his name from Pulverizer Pete to Pulverized Peat.

You know, Ed, being born and brought up in these here U.S., its kind of hard to get a relief check, and seein' as I have left the old job at the powerplant I am in the market for a new one. Of course the old woman makes a couple of dollars now and then by takin in washing, but it seems that all the Chinamen what ain't been bombed out of Shanghai is runnin opposition, and things ain't all they could be.

So the other day I sees an ad in a newspaper what I found in the park, what says that they need a bright young technical assistant for development work. So I goes right down there, and the feller what does the hiring asks me about my experience. After I tells him that alongside of me, Edison looked like a kid playing with a "Fun with Electricity" set he says that I am just the man they are looking for in their test laboratory. I asked him what they was testing, and he said, "A new lie detector".

He takes me into the laboratory where there is a funny looking gadget like a 1950 model radio set ought to look, and he sits me down in a chair and starts the machine going. He asks me a few questions and then says, "Why did you leave your last job?". So I started to tell him how it happened, but before I got halfway through there was a loud noise and the machine busted.

The feller looks at me funny and says that he thinks that I am too good, and that maybe he better not hire me. I tells him I know that I am good, but that he shouldn't worry, on account of I do not want a very high salary. He says that he is afraid the law won't let him pay me what I am worth, and when I asked him what law, he says the Minimum Wage Law. You know, Ed, sometimes I think that we got too goldarn many laws.

So then I takes my broom and pail and goes around from house to house trying not to get jobs cleanin winders and sellars and things like that. I rings the bell in one house, and the guy that comes to answer the door nearly scares me skinny. Honest, he looked like a picture from a book I saw called Arabian Nights. He has on a pair of baggy pants, a funny lookin bath robe, and about ten yards of bandage around his head. Gosh, he sure did look like thirty-nine of the forty thieves. I finally asks him has he got any odd jobs, and he looks at me a long time and tells me to come in. I was scared to go in and more scared not to, so I walks in after him.

He sits me down in a room full of curtains with stars and moons on them, and a lot of queer thing-um-bobs all over the place. I heard him talking to somebody in another room, and I heard him say something about an "excellent experimental subject". Soon he comes back with a dame that was as odd as he was. Her name was Madame Zozo, and she was a medium. Now to me medium always meant the way I like my steak, when I can afford steak, but it seems that this dame was kind of a Charlie McCarthy for a spook.

She looks me over careful like, and asks me have I ever been mesmerized. I told her plenty of times, only we didn't call it that. So she makes me look into a big glass ball, and says some funny words in Eyetalian or something, and pretty soon I gets to feelin kind of empty inside and drowsy like, and the first thing you know I am asleep.

When I woke up, I was way out in the country somewheres. The darned robbers went and swiped my broom and pail, and I didn't have the least idea where I was. It was hot as the dickens so I sits down under a tree, thinkin maybe I can bum a ride from the first

jalopy what comes along. Pretty soon a feller comes walkin down the road wearin nothin but his underwear, and not very much of that. I calls out and asks him where I am, but the coot takes one look at me and lights out like a bat outa—well anyhow he was goin places. I figures that he knows where he's goin, so I follows him.

After I turns the bend in the road, I see a building what looks like a imitation of the Masonic Temple back on Main Street. It was all white and shiny, so I thinks that I'll go in and find out where I am. The place is full of nuttiest bunch of junk that you ever saw. Crazy clocks, levers, gear wheels that looked like they had been chewed out, and such like. Thinks I,

"Is that so?" I sez. "What makes you a Hero?"

I must be in the patent office at Washington. An old guy with whiskers like Sandy Claws and wrapped up in a bed sheet is sittin on the floor playin with a copper ball what is mounted on some kind of a stand. Steam is comin out of a sort of nozzle on each end, and the ball is spinnin round like a top. The coot is so excited about the thing that he never notices me. I begins to think that maybe this ain't the patent office, but the county goon asylum.

"Hey, Pop," sez I, "can you tell me where I am?"

The old guy looks up, and when he sees me he acts kind of scared.

"And who might you be?" he asks me after a while.

"I might be Garbo, because I want to go home, but you can call me Pete. What I want to know is where am I."

"You are indeed a strange creature," sez he. "Know you not that this is Alexandria?"

"Alexandria?" sez I, "I never heard of it. What real town is it near?"

"And know you not that Alexandria is the metropolis of Egypt?" he sez.

Well, Ed, I begins to get a little scared about this time, and starts edgin toward the door. But the old guy takes me by the hand, and starts tellin me all about the play toy on the floor. Finally I asks him what it was.

He stands up kind of proud like, and sez, "This, my son, is the world's first steam turbine."

"Yeah," sez I, thinkin about the 25,000 kv-a. watch charms at the power plant, "and I'm Napoleon. The lawn sprinklers they sell in the dime stores back home work better than that. But say, Pop, what makes that thing run, anyhow?"

"Alas, my son, I do not know. It will be nearlyy two thousand years yet before Thermodynamics is invented."

Believe you me, Ed, I knew where I was then. I was just about to yell for the keeper, but I decides the guy is harmless, and that maybe I better humor him. So I asks him what his name is just to keep him talkin.

"And do you not know that I am Hero of Alexandria?"

"Is that so?" I sez. "What makes you a Hero?"

Just then there is an awful flash of lightning, and a clap of thunder like I never heard before. The old guy never blinks. He just shakes his head sadlike, and sez, "There goes old Zeus playing with that fool dynamo of his again. I keep telling him to wait a few thousand years until Edison is born, but he will not listen to me."

Ed, enough is enough, and I dives for the door, but just as I gets outside another flash of lightning knocks me cold. When I comes to, I am back at Madame Zozo's, and she and Ali Baba is laughing like the old nick. They gives me my broom and pail and two bits besides, and tells me to come back again soon.

I been thinkin and thinkin about the whole mess, and it don't make sense nohow. Do you think maybe I could be goin nuts?

Hopin you are the same, I am

Yours, etc.,

PULVERIZER PETE'S STOOGE.

Coal Ash Tests

AT THE ANNUAL MEETING of the A. S. T. M., the Committee on Coal and Coke submitted a new method of sampling coals classed according to ash content. This is applicable to ordinary commercial sampling and is designed to have an accuracy such that in 95 cases out of 100, the ash content of the sample will be within plus or minus 10 per cent of the true ash content of the coal samples. A modification of the method is given also for conditions requiring greater accuracy. In the proposed method, coals are divided for sampling into four groups, depending on ash content, and each group is subdivided according to size of coal. The minimum size of increments as given is based on the quantity of coal necessary to represent the true size of the coal sampled.

A tentative revision was approved for publication in the standard methods of laboratory sampling and analysis providing for a change in the method for determining fusibility of ash to give essential furnace requirements and mention of specific furnaces which the committee has approved. A special section of the committee was formed to investigate plastic properties of coals as affecting their combustion characteristics. In connection with testing expanding properties of coal during carbonization in coke ovens, arrangements are being made to distribute samples of coal of various ranks to different laboratories for making expansion tests by different methods. Such preliminary cooperative testing is believed necessary in the selection or development of a standard test procedure.

Sewage Makes Good Power

New half million dollar sewage treatment project at LaCrosse, Wis., built to handle 2 billion gals. annually and take care of all station power and heating from gas generated in digesters from sewage sludge.

By C. A. Wahlstrom,
Supt. of Station, City of LaCrosse,
and
H. T. Rudgal,
Res. Eng. Alvord, Burdick & Howson

TO HANDLE the ever growing problem of sewage disposal, LaCrosse, Wis., last year completed a new treatment plant using the primary treatment in which no chemicals are required at any stage of the process. Sand, grease and scum are removed from the raw sewage, the clear effluent discharged and the raw sludge pumped to digesters where anaerobic decomposition takes place. The resulting sludge is dried and has some value as a fertilizer, while, the gas from the digestion process is utilized to make all the power required in the plant and take care of all heating needs of the building and process.

The new plant, located on the Mississippi River bottom on filled-in land, will: Treat approximately 2 billion gallons of sewage annually; remove 6500 cu. ft. of sand and grit, 650 cu. ft. of grease and scum; and treat 17,000 cu. yd. of wet sludge to produce as a by-product 11,000,000 cu. ft. of sewage gas for power and heating and end up with about 1600 cu. yd. of odorless dry sludge. The flow through the plant is shown by Fig. 1. Raw sewage from the city enters the plant, through a 42 in. diam. sewer, by gravity—part having been pumped to the gravity sewer from three sewage pumping stations. All sewage reaching the treatment plant must pass through Chicago Pump Co. Comminutors or shredders, 2, which cut or shred coarse material.

When this coarse matter is cut into sufficiently small particles, it flows through the slots with the sewage into a suction well adjacent to a pump pit in which are located two electrically driven, vertical shaft American Well raw sewage pumps, 3, one of 4 and the other of 8 m.g.d. capacity. These pumps, automatically operated by a float switch, take sewage from the suction well and lift it approximately 25 ft. into the discharge channel at the south side of the pump motor room. From the pump discharge channel the sewage passes to the grit remover or Dorr detritor, 4, where the heavier particles such as sand, cinders and grit settle to the bottom of the tank. Revolving scrapers and a mechanical rake work the grit up an incline, wash out the sewage or organic matter and dump the grit into industrial railway cars. This material is practically odorless and is used for fill at the plant site.

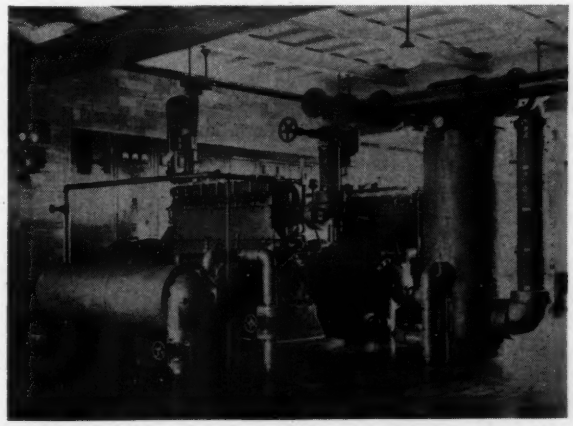


Fig. 2. General view of the engine room with the switchboard cubicles visible over the top of the engines, the horizontal heat exchanger in front of the engines and the vertical waste heat boiler which serves both engines at the right.

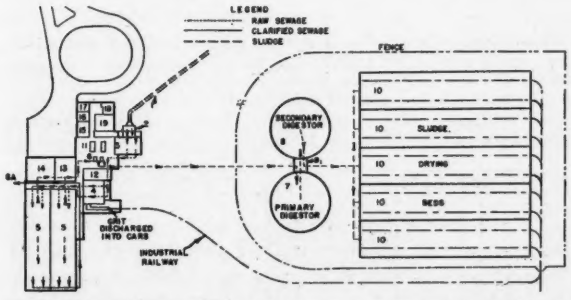


Fig. 1. Flow diagram showing the general arrangement of, and the course of the sewage through the plant. Treatment plant, intercepting sewers and appurtenant structures, were built at a cost of $530,000, but with the 45 per cent P. W. A. allotment, the net cost to the city was $291,000. 1. Raw Sewage. 2. Comminutors. 3. Sewage Pumps. 4. Grit Tank. 5. Clarifier Tanks. 6. Sludge Pumps. 6A. Sewer to River. 7. Primary Digestor. 8. Secondary Digestor. 9. Control House. 10. Sludge Dry Beds. 11. Engine Room. 12. Boiler Room. 13. Shop. 14. Garage. 15. Locker Room. 16-17, Lavatory. 18. Office. 19. Laboratory.

Sewage from the grit tank then flows over a weir into another concrete channel to two clarifier or settling tanks, 5. During the 2 hr. required for flow through these tanks about 90 per cent of the settleable solids fall to the bottom. The affluent or settled sewage then flows to a 30 in. outfall sewer, 6A, through a venturi meter which measures and records the flow.

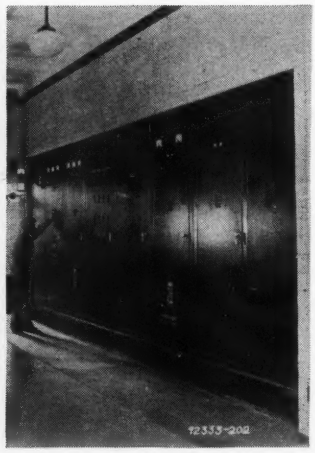


Fig. 3. View of the two engines with the jacket circulating water pump in the foreground and the switchboard at the right. These two photographs were taken from about the same position but the camera was turned slightly so as to get two different views. The end of the exciter visible at the operator's knees on the right hand view is the same as the one in the foreground of the left hand view.

and is discharged into the river through underwater outlets approximately 100 ft. from the river bank.

Settled matter, or sludge, on the bottom of the clarifier tanks is scraped into hoppers at the north end of the tanks, by wood flights mounted on endless chains. This Chain Belt clarifier equipment is driven by Louis Allis motors. As the flights or scrapers move to the south or outlet end of the tanks, their course is at the top of the sewage level and all floating scum and grease is moved to the far end of the tank. Here it is allowed to collect and then is raked into the grease trough and intermittently pumped into the primary digester tank.

Two Yeoman Bros. sludge pumps, 6, located in the engine room draw sludge from the settling tank storage hoppers and pump it into the primary digester tank, 7, located 200 ft. east of the main building. The tank is of concrete and provided with a gas holder with a floating type cover. Here the sludge, of which approximately 60 per cent is subject to putrefaction, is allowed to digest or ferment. Anaerobic decomposition breaks down the sewage solids in the sludge, thereby promoting sewage gas production and reducing the bulk of the sludge about one half. The gas produced is used for heating and power. From time to time sludge is drawn from the primary tank into the secondary digestor tank, 8, where the digestion process is completed. This tank is similar in construction to the primary tank except that the tank is not heated and the steel floating cover is designed to allow 10,000 cu. ft. gas storage space above the level of the sludge, to take care of variations in gas production and use.

Between the two digester tanks is the digester control room which provides space for all of the control piping and valves, gas meters for measuring the flow of gas, sulphur removers and sampling connections.

In the spring and fall the digested sludge is discharged from the secondary tank to the sludge drying beds, 10. There are five of these beds, constructed of sand and underdrained with four lines of 6 in. open jointed tile pipe, surrounded with gravel. The digested sludge as discharged to the beds is in the form of black mud without odor or disagreeable properties and dries quite rapidly. After drying out, the sludge is scraped from the beds. It has some fertilizing value and is used at the plant site in beautifying the grounds or given away to residents for use on lawns and shrubs.

Details of the engine and boiler room arrangement are shown by Fig. 5 and the photographs Figs. 2 and 3. All power requirements are taken care of by two 90 hp., 720 r.p.m. Worthington gas engines driving 60 kw., 3 ph., 60 cycle, 480 v. Allis-Chalmers generators with 3 kw. direct connected exciters. Each of these engines has a Sims heat exchanger on the jacket water cooling system and the heat reclaimed is used in the primary digester. The jacket water, pumped by Worthington pumps driven from

Table I. Summary of operating data since the plant has been in service. Quantity values are daily averages for the month. Over the period from January to May the maximum and minimum daily flows recorded were (10.88) and (2.36) M.G.D. and the 1 hr. rates were 14.75 and 0.65 M.G.D. Other maximum and minimum daily quantities were: gas produced 75,550 and 26,100 cu. ft.; gas used 35,230 and 21,910 cu. ft.; power produced 1109 and 447 kw-hr. The overall thermal efficiency of the plant from the standpoint of engine performance has been increasing steadily and was 14.6 per cent in March, 15.4 per cent in April and 16.32 per cent in May. The population of the city is approximately 40,000 and the gas per capita generated ranges from 1.89 to 0.65 cu. ft. per day.

MONTH	AV. TEMP. °F.		PRECIPITATION, IN.	RAW SEWAGE				RAW SLUDGE		DIEGESTER TEMP.				GAS DATA							ENGINE DATA									
											PRIMARY TANK COOLING WATER, DEG. F											JACKET WATER TEMP DEG.F.				OIL TEMP. °F.		
	MAX.	MIN.		TOTAL FLOW 1000 GAL.	SCUM. GAL.	GRIT CU.FT.	TOTAL SOLIDS P.P.M.	TOTAL GAL.	DRY SLUDGE LB.	PRIMARY TANK DEG. F	IN	OUT	SECONDARY TANK DEG. F	PRIMARY TANK CU. FT.	SECONDARY TANK CU. FT.	CU. FT. PER CAPITA	USED IN ENGINES CU. FT	HOUSE USE CU.FT.	SURPLUS CU. FT	TOTAL POWER K.W.H.	USED BY PUMPS K.W.H.	HOUSE & MOTORS K.W.H.	NO. 1 IN	NO. 1 OUT	NO. 2 IN	NO. 2 OUT	NO.1	NO.2	TOTAL OIL USED QT.NO
DEC.	27.0	14.0	0.01+	3440	63	212	832	12,810	5392	——	——	——	——	19,411	——	——	——	——	——	578	412	166	——	——	——	——	——	——	130.0
JAN.	24.6	11.3	0.03+	4117	—	17	1055	12,007	8555	85	127	116	65	28,838	4496	——	23,190	1055	9303	601	417	184	133	149	133	149			195.0
FEB.	33.8	20.4	0.03+	5111	324	20	956	13,825	8618	84	125	111	64	35,685	8121	1.22	25,265	2052	21,289	685	491	174	128	144	127	144	146	156	84.7
MAR.	48.4	30.9	0.10	4768	206	22	824	16,959	11,244	87	131	119	68	37,415	18,086	1.39	27,039	869	27,655	691	517	174	133	149	131	145	149	156	93.5
APRIL	57.7	39.7	0.10	5071	143	23	779	19,056	10,354	85	130	110	71	31,499	14,670	1.15	27,609	815	14,408	745	558	189	132	149	133	148	151	155	102.5
MAY	67.0	49.3	0.22	6606	137	30	812	14,286	9063	81	131	110	76	29,691	4418	0.85	28,079	810	4155	864	689	175	131	148	132	148	153	153	88.5
JUNE	77.4	58.7	0.13+	6244	—	35	865	15,411	9163	84	133	113	80	58,854	——	——	28,498	806	——	817	670	147	130	145	127	143	152	151	64.5
JULY	88.0	70.0	0.23–	6219	—	40	693	14,851	7295	83	126	112	82	——	——	.077	28,633	745	1495	849	670	149	126	144	129	142	151	156	81.5

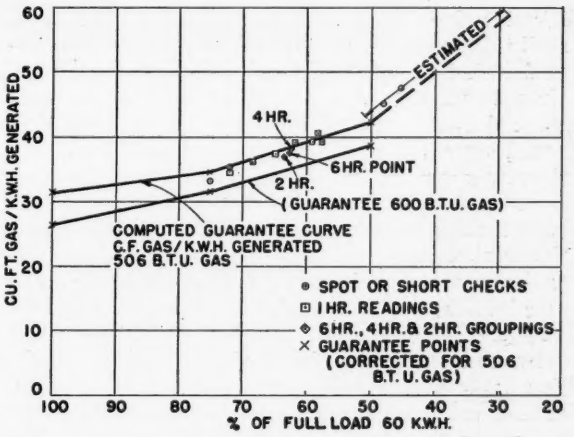


Fig. 4. Test curve of Engine No. 2 operating on 506 B.t.u. gas. Tests on No 1 engine are very similar. Guarantees were based on 600 B.t.u. gas and on 6 and 6½ hr. tests at about 62 per cent load both engines consumed 0.1 cu. ft. per kw-hr. less than the corrected guarantee values. The gas analysis in per cent is: CH_4, 51.5; CO_2, 43.1; N, 4.2; CO, 0.8; and O, 0.4.

the engine shaft, has a temperature range from about 133 to 148 deg. F., an increase of about 15 deg. F. from the engine operation. On the digester side, the temperature runs about 130 to 110 deg. F. due to a 20 deg. F. cooling range through the digester.

In addition to the heat exchangers, both engines exhaust into a Sims waste heat boiler followed by a Maxim silencer. So far the jacket water heat exchangers have proved capable of handling the digester heating and because there is an excess of gas, the building heating system has been carried by a Bryant tubular gas boiler with forced circulation. A Crane gas heated hot water heater is also provided for the showers. Both boilers, the two Chicago circulating water pumps (driven by ½ hp. Baldor motors) on the heating system and Metric gas meters on the engine and boiler system, are located in the boiler room, as shown on Fig. 5. The two heating systems may be operated in parallel or separate, and, because of the limited amount of heat required by the digesters, the latter has proved to be more satisfactory.

Each engine is equipped with Vortex cleaners on the air intake, Bendix magnetos, Pickering governors, Automatic Switch solenoid trip on the gas valve, Minneapolis-Honeywell automatic pressure and temperature stops, Weston exhaust gas temperature indicators and Crane valves and exhaust piping. The Chicago sump pump in the corner of the engine room is driven by an Allis-Chalmers 2 hp. motor with a Square D float switch, and the flushing pump is of the same make, but is driven by a 5 hp. G.E. motor. The Yeomans Bros. sludge pumps are each driven by a 1 hp. Master motor through gears, the American sewage pumps by 25 and 50 hp. Harnischfeger motors and the Comminutors by Allis-Chalmers 2 hp., 1750 r.p.m. motors through Universal 8.5 to 1 gears. All motors operate at 440 v. The sewage meter is a Bailey recording type and the gas meters are all Metric. The starting air compressor is a Worthington 2 cyl. vertical unit Multi-V belted to a Novo single cylinder gas engine.

All flushing water for the plant is taken from a storage tank kept full from the city system by a Fisher float control.

For emergency operation on gasoline, Zenith carburetors have been provided and a small elevated gasoline tank on the wall is kept full by a Tuthill pump, driven by a ¼ hp. motor with a Mercoid switch control, and taking its suction from a 500 gal. outdoor, underground gasoline storage tank.

The central control board, the top of which is visible behind the engines in Fig. 2, consists of eight sections of Cutler Hammer switchboard cubicles set flush with the wall and with all instruments flush mounted. One of these panels is blank for a circuit breaker and provisions for outside service should this prove necessary in the future; the second and third are for the 4 and 8 m.g.d. sewage pump motors; the fourth, with the bus bar work and supports, includes no control equipment; the fifth is the control panel for some 12 small motors ranging up to 7½ hp.; the sixth and seventh are the generator panels; and the eighth, at present a fillin panel, makes provision to handle the future generator for which space has been provided in the building.

Alvord, Burdick & Howson of Chicago were the consulting engineers; Theo. V. Molzahn & Sons, Inc., of La Crosse, Wis., the general contractors; John Papenfuss of La Crosse the electrical contractor; and Thomas Heating Co., of Racine, Wis., contractors for all pipe work and gas engine installation. The project came under the City Engineering Department of La Crosse of which John Barth is chief engineer.

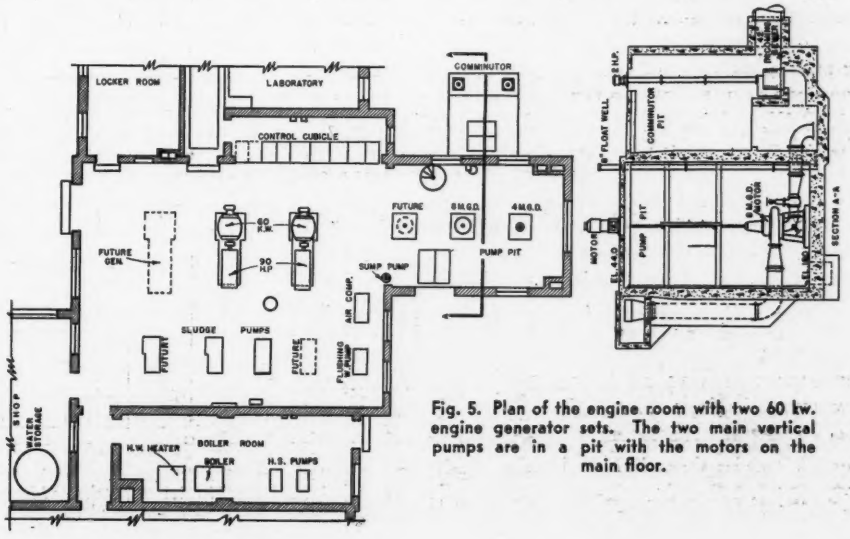


Fig. 5. Plan of the engine room with two 60 kw. engine generator sets. The two main vertical pumps are in a pit with the motors on the main floor.

Diesel Cooling Water Supplies

Importance of cooling water on engine performance warrants close study of the economic factors involved in providing a proper supply. Various methods of cooling, their advantages and disadvantages discussed before the A. S. M. E. Dallas Meeting.

By GUSTAVE J. BISCHOF

Consulting Engineer
The Cooling Tower Co., Inc.
New York, N. Y.

SCARCITY or high cost of water and frequently problems of disposal necessitate recooling and re-use of water rather than running it to waste. A cooling tower saves about 95 percent or more of the water. When soft water is available for makeup, open systems can be used. In such cases the jacket water itself is pumped through the engine and over some form of tower and then recirculated through the engines. The choice of the particular type of tower depends largely on location and cost of ground space. In order of ascending investment, costs are: spray ponds, spray atmospheric towers, deck-atmospheric towers and mechanical-draft towers. This also is the order of decreasing ground space required. Unless a pond of considerable extent already exists with cheap ground rent, spray pond equipment, despite its low first cost, will prove expensive. At the other extreme, forced-draft towers, with their higher initial and operating costs, occupy small ground space (especially filled induced-draft types), need no exposure and are even adaptable for indoor use.

Radiators have found a wide application for cooling engines of small and medium size. They are particularly suitable for portable field engines and in some cases for indoor installations. As they do not employ the principle of evaporation, they are free from scale deposit and make-up water requirements. On the other hand, they require large air movements with consequent high fan power consumption. If off-engine water temperatures are to be kept below 160 deg. F. under high dry-bulb conditions (exceeding 100 deg. F.) their size and horsepower make them uneconomical.

The evaporative condenser was designed primarily as a combined cooling tower and condenser for refrigerant condensing, but it is also finding a field in Diesel-engine cooling. It consists of a sheet-metal shell through which air travels vertically by induced- or forced-draft fans. In the path of the ascending air are located a series of tubes carrying the soft water in a horizontal direction. These tubes have finned surfaces and a spray nozzle system discharges the raw water over the fins where evaporation occurs. Excess water collects in a pan from which it is pumped back to the nozzles together with the make-up water. The equipment is essentially an evaporatively cooled radiator requiring about half the amount of air necessary for a dry radiator. Jacket water is cooled through a 20 deg. F. range with off-engine water temperature between 140 and 160 deg. F. The raw-water circulation is low compared with other types of heat-exchanger systems, being only about one-third of the soft-water circulation.

The evaporative-radiator system seems well adapted to small and medium-sized engine installations, forming a compact unit for indoor closed systems from which the moist air is discharged to the exterior through ducts. A serious disadvantage is the accumulation of insulating scale on the fins, resulting from scale deposits left by the evaporation of the raw water.

Economy of Closed vs. Open Systems

Trends to closed-cooling sstems in preference to open systems have been so marked in recent years that the writer undertook to establish total yearly costs and analyze the components of these costs for both systems over a wide range of engine sizes. For the open system the investment covered a spray type atmospheric tower mounted over a concrete foundation-basin, all erected in place, together with a suitable pump and motor for water circulation. Cooling was from 115 deg. F. to 95 deg. F. at 75 deg. F. wet bulb. This resulted in a circulation of 0.3 g.p.m. per hp. Closed-system investment included a much larger spray type atmospheric tower, with atmospheric-tube heat exchangers mounted in the base, and all erected over a concrete-basin foundation. Included also in the in-

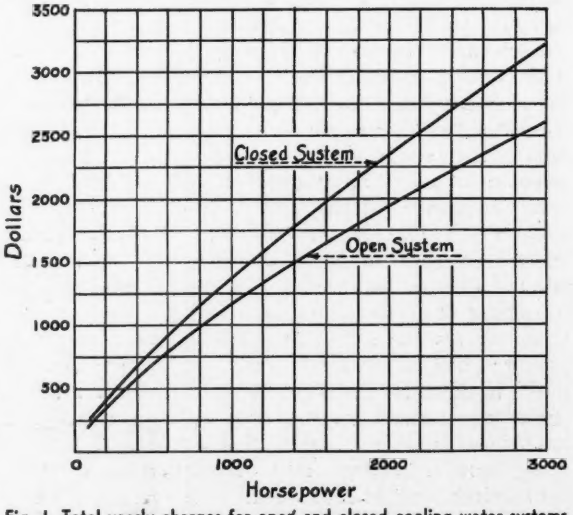


Fig. 1. Total yearly charges for open and closed cooling water systems as a function of plant size. These total charges are divided as shown by Fig. 2.

Abstract of a paper presented before the 11th National Oil and Gas Power Meeting of the A. S. M. E. at Dallas, Tex., June 6-9, 1938.

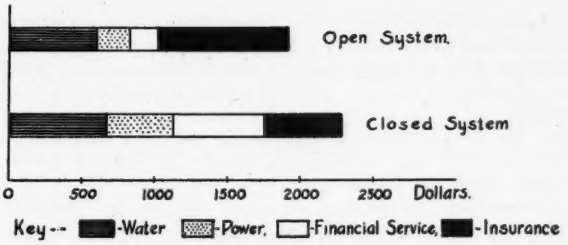


Fig. 2. How the total yearly charges are divided in an installation of about 2,000 h.p.

vestment cost were a raw- and a soft-water circulating pump with motors. The jacket-water cooling was much higher in the temperature scale (a permissible and desirable condition with closed systems), being from 140 to 125 deg. F., with both raw- and soft-water circulation at 0.4 g.p.m. per hp. No piping was included for either type of system. The investment costs, depending on size of installation serviced, varied from $4.00 to $1.00 per hp. for the open systems and from $11.00 to $3.00 for the closed system. Fig. 1 graphically illustrates the variation of total yearly charges for both systems, servicing installations from 100 to 3000 hp.

Total yearly charges were composed of investment charges, operating charges (pumping cost and make-up water) and insurance. Investment charges as taken were based on five per cent interest on installation cost, and yearly equalized depreciation payments for ten years into a sinking fund compounded annually at five per cent interest. The operating charges assume 3000 hr. operation per yr. and make-up water costing $1.00 per thousand cubic feet and electric current at 00.01 per kw-hr. The insurance rates were based on engines built after the year 1925, paid in three-year premiums and are the so-called "objective charge" to which is added a small insurance charge (not included).

Figure 2 analyzes the above components for a cooling system servicing a 2000 hp. installation. It is interesting to note that while power charges (because of double pumping), and financial charges (because of larger investment) are materially higher for the closed system, the low insurance rates, due to its use, make total yearly charges only about 20 per cent higher than for the open system. The insurance component is a measure, in some degree, of the engine-repair costs but when other items associated with trouble-free and uninterrupted service are considered, it is readily seen that closed systems are economically justified unless very soft water or elaborate treatment is used.

Where water is very scarce, or of such quality that treatment becomes imperative, the quantity of make-up water required is important. Water lost by evaporation is a direct function of the heat dissipated and is roughly equal to one pound for every 1000 B.t.u. To this amount must be added a constant driftage loss which depends upon the water circulation, the kind of equipment and its design. In very general terms and under average wind conditions a spray pond loses three to five per cent of its circulation, an atmospheric tower one to one and one-half, and a mechanical draft tower with proper eliminator system one-fifth to one-half.

A recent questionnaire sent to leading American Diesel and gas engine manufacturers disclosed that the heat to be dissipated by the cooling water varied from 1300 to 3500 for Diesel engines and for gas engines from 3800 to 5400 B.t.u. per br. hp. hr. The figures depend upon design and whether or not exhaust manifolds and pistons are cooled. With such wide variations, generalizations are dangerous but in the great majority of cases the values for Diesel engines were between 2500 and 3000, while for gas engines they ranged from 4000 to 5000 B.t.u.

A convenient chart for establishing circulation in accordance with cooling range and vice versa, when once the heat to be dissipated by the cooling water per hp. per hr. is determined is shown in Fig. 3. In general, ranges should be kept low (12 to 30 deg. F.) and circulation of jacket water high so as to reduce thermal stress and secure turbulent circulation without dead pockets for steam formation and scale deposit. Partial recirculation is often advisable with thermostatic control, keeping off-engine water temperatures uniform without changing jacket-water circulation. The purchaser, by a wise choice of such cooling conditions as lie within his power of modification, may obtain a reasonably sized cooling tower to give complete satisfaction at a reasonable price.

Analyzing each condition separately we find that: The size of a cooling tower will be in direct proportion to the quantity of water circulated and cooled; for equally close approaches to a wet bulb, a low wet bulb requires a larger tower and the percentage increase of tower size increases as the wet bulb falls; for equal cooling ranges, the closer approach to the wet bulb required of the off-tower water temperature, the larger is the necessary tower size. So close wet bulb approaches call for disproportionately large tower sizes; increasing ranges of cooling (greater difference between on- and off-tower water temperatures) do not require proportionately larger towers. Hence, it is more economical, for a given heat dissipation, to raise the on-tower water temperature and decrease the quantity of water circulated.

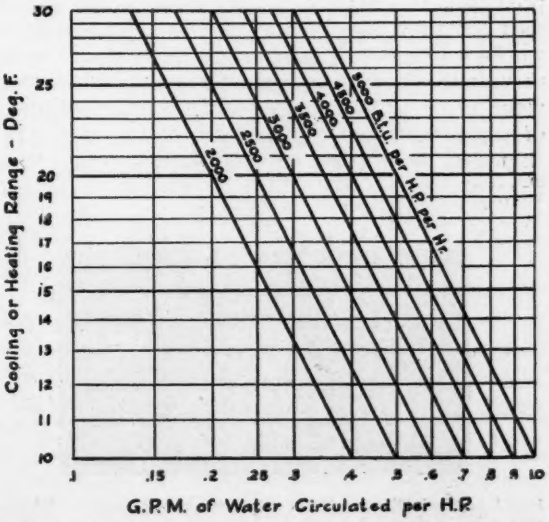


Fig. 3. Relation between the cooling range and amount of water required for cooling purposes.

Part XXIX

The Leyden Jar was one of the earliest pieces of electrical equipment. Long before it had any practical uses, its strange power of holding electric charges and releasing them in the form of brilliant sparks gave it a prominent place in genteel parlor amusement in early polite society. Later, under its more technical name of condenser, it was used for certain practical purposes in circuits but it was not until quite recently and particularly since the advent of the electron tube that the condenser came into its own. Today it is used in thousands of ways in all types of circuits. The three applications described in this article in combination with electron tubes will be of special interest to those concerned with electric power generation.

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

WE HAVE CONSIDERED briefly the application of electron tubes and electronic devices in the field of measurement and instrumentation. Because of its all but limitless sensitivity and its inconceivable speed of action the electron tube is adaptable to almost any type of measurement and in many instances accomplishes things that could not possibly be accomplished without tubes.

If, however, electronic devices have proved of value in the field of measurement, they are perhaps even more useful for control purposes. For control is merely an extension of measurement and the sensitivity and speed of action of electron tubes enables them to meet the demands of almost any control problem that may arise. In previous articles, we have seen how they have been applied in the protection of gas fired furnaces. This is merely one instance among thousands. Today, electronic devices are rapidly supplanting electro-mechanical devices in a multiplicity of applications and new uses are being found daily. In many cases tubes are performing duties which could not have been done with the electro-mechanical devices previously available.

[1]Part XXVI, June 1938, p. 386

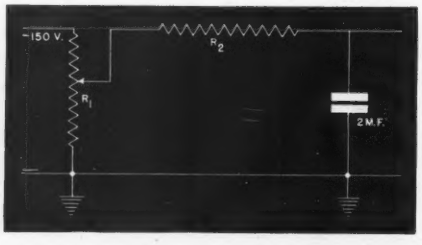


Fig. 1. This is the condenser discharge circuit used to introduce time delay in electrical circuits for certain control purposes. The rate of charge of the condenser is dependent upon the capacity of the condenser and the resistance of R_2

Despite the multiplicity of uses, high vacuum tubes have only one important ability in control problems and that is in cases where substantial voltage changes are available for initiating control but where only very small quantities of current are available. In other words, the grid-controlled high vacuum tube is essentially a high-impedance control device, and it serves satisfactorily only where a high impedance source of control is used as the controlling agent.

Suppose we consider a circuit such as shown in Fig. 1. This consists of a resistor and capacitor combination. A voltage source obtained across a voltage divider R_1 is used to charge a two microfarad condenser through a variable resistor set at its maximum value of 50 megohms. If the voltage across the divider is 100 v. the voltage across the divider will become 63 v. at the end of 100 seconds after the charging begins. The rate of voltage increase is, of course, dependent upon the capacity of the condenser and the rate at which current flows into it; with a fixed capacity, the higher the resistance, the slower the rate of charging.

If the resistance in series with the condenser in Fig. 1 is reduced from 50 megohms to its minimum value of 0.1 megohm, the voltage across the condenser becomes 63 v. only 0.2 second after charging begins. Considering 63 v. as a control reference, any time delay from 0.2 second to nearly two minutes may be obtained simply by adjusting the resistor R_2.

The idea involved in this circuit is simple but it is not a simple matter to measure the voltage across the capacitor. The resistance of any voltmeter or other voltage measuring device must be very high; if it is not, the capacitor will discharge through the

resistor windings faster than it can charge through the resistor.

The solution to this problem, as may have been suspected, lies in the electron tube voltmeter described in an earlier article.[1] The input resistance of the electron tube voltmeter is extremely high and furthermore the circuit may contain relays for cutting in or out other circuits when the condenser voltage has increased to the reference value.

This combination of a condenser discharge circuit and an electronic tube provides the fundamental elements for indicating the rate of change and the direction of change of an electric potential and it has many applications, three of which are of direct importance in central station control problems, these are, the impulse relay, the electronic voltage regulator and the automatic synchronizer.[2]

Consider the circuit in Fig. 2 which is similar to the one in Fig. 1. The current through tube 3, for a definite plate voltage E_p depends upon the voltage E_g of the grid bias battery 4. If a voltage E_1 is applied with a polarity as shown, a charging current will flow through resistor 2 to the condenser. This charging current will produce a voltage drop across the resistor with a polarity as indicated. Consequently the bias on the grid of tube 3 will become more positive and the current through the tube will increase. After a definite time, dependent upon the time constant of the discharge circuit, the condenser will be fully charged, and the charging current, and consequently the voltage drop across the resistor, will become zero, so that the current through tube 3 will come back to the original value as determined by the grid bias battery. If now voltage E_1 is varied a voltage drop across the resistor takes places which is essentially proportional to the rate of change of E_1 and the polarity of this voltage drop will reverse if the direction of change of E_1 is reversed. The important features of this circuit are that the output of the tube is not affected by the magnitude of voltage E_1 but only by the rate of change of E_1 and further, that since resistor 2 may be several megohms only a minute amount of control power is needed.

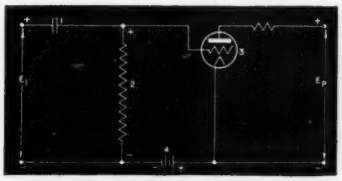


Fig. 2. The fundamental condenser discharge circuit as used with a thermionic tube for measuring the rate of voltage change of E_1

A scheme for an impulse relay for quick response excitation voltage regulators, using this condenser discharge principle, is shown in Fig. 3. With this type of equipment it is highly desirable to provide additional field forcing by shunting out all resistance in series with the exciter fields if a sudden drop in regulated voltage should occur.

[1]Part XXVI. June 1938.

[2]The Principle of Condenser Discharge Applied to Central Station Control Problems. F. H. Gulliksen. Paper presented before A.I.E.I. January 1933.

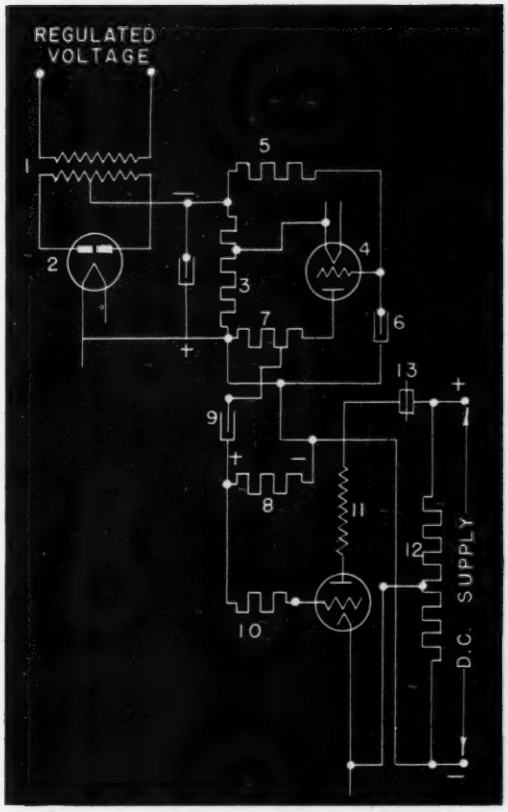


Fig. 3. Circuit diagram of the electron tube impulse relay

A transformer 1 is connected to the regulated voltage source and feeds into the full wave rectifier tube 2. The direct current voltage across resistor 3 will, therefore, be proportional to the regulated voltage. An amplifier tube 4 is connected to resistor 3 in such a manner that the plate current of tube 4 does not change if the regulated voltage changes slowly. This condition is obtained by selecting the location of the resistor tap so any change in tube plate voltage is compensated for by a proportional change in grid bias voltage. A resistor 5 and a condenser 6 are connected in a discharge circuit to the grid of tube 4 so that for decreasing regulated voltage the grid of tube 4 will become more negative and consequently the voltage drop across resistor 7 will decrease due to the decreased plate current of tube 4. When the voltage drop across resistor 7 decreases, a voltage drop will appear across resistor 8 due to the discharging action of condenser 9. The polarity of the voltage drop across resistor 8 will be as indicated in the diagram, so that the grid voltage of the glow tube 10 becomes more positive and causes tube 10 to break down and energize the quick response shunting contactor coil 11. Contactor 11 remains closed until the direct current supply voltage for tube 10 is disconnected by means of the contacts 13 of the field current limiting relay. The d.c. supply for tube 10 is supplied from the 250-v. station bus through the voltage divider.

According to F. H. Gulliksen of the Westinghouse

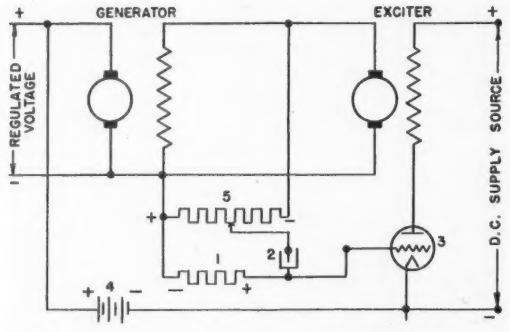


Fig. 4. Schematic diagram of an electronic voltage regulator using the condenser discharge principle

Electric and Mfg. Co., the response of this equipment compares favorably with the electro-mechanical quick response voltage regulators at their best and the response does not depend upon the voltage conditions immediately before the fault occurred as is the case with the electro-mechanical regulators.

Voltage Regulation

Since the condenser discharge circuit is so sensitive to voltage changes, it is obvious that this principle is well adapted to voltage regulation and this is the case; it is an important feature of several electronic voltage regulators which have been placed on the market. Such regulators are now available for direct current and alternating current generator voltage regulation. The important features of these electronic type regulators are the high sensitivity, the simplicity of operation and the extremely fast response characteristic. This fast response characteristic is made possible through the application of the condenser discharge as an anti-hunting means.

Because of the inductive lag of the field windings of exciters and generators, the generator armature always lags in relation to the exciter field current, if the exciter field current undergoes a change as a result of regulator action. If no anti-hunting action is provided, the generator armature voltage will not have reached the normal value when the exciter field attains the value corresponding to the new generator load conditions. As a consequence, when the generator voltage is brought back to the normal value, the exciter field current will be too high if the regulator action was caused by a drop in the regulated voltage and even though the regulator immediately starts to decrease the exciter field current, the generator armature voltage continues to increase for a definite time dependent upon the time lag characteristic of the machine combination. Naturally, such a system will be unstable unless a zone is introduced within the limits of which the voltage being regulated can vary without bringing into play the field current correcting forces.

In the electron tube regulator for d.c. generators described by F. H. Gulliksen, the exciter field winding is connected in series with a 3 electrode tube as shown in Fig. 4, the plate voltage of which is supplied by a separate d.c. source. The generator voltage is opposed by means of a battery so that increasing generator voltage will increase the negative bias on the grid of the tube and thus, decrease the exciter field current.

The anti-hunting is obtained through the condenser discharge circuit consisting of a resistor 1 and a condenser 2 which is connected in series across the exciter armature. When the exciter armature voltage is decreasing the polarity of the voltage drop across the resistor 1 will be as shown in the diagram and will, therefore, provide a positive bias on the tube. This positive bias counteracts the original negative bias resulting from the initial increase in regulated voltage and consequently tends to stabilize the equipment.

In this, as in our preliminary consideration of the condenser discharge circuit, it should be noted that the amount of anti-hunting force is proporional to the rate of change of exciter armature voltage and that consequently the anti-hunting force is zero until the exciter armature voltage starts to change. The anti-hunting action does not tend to decrease the initial response of the field current change. The anti-hunting action is controlled by means of a small radio type potentiometer shown in Fig. 4.

This type of voltage regulator using the condenser discharge principle is one of a number of different types of voltage regulators using electron tubes which have been developed. While these regulators have by no means supplanted the electro-mechanical type for large capacities, their use for small units is increasing and there is no reason to believe that ultimately they will not be used for large generators. As will be shown in subsequent articles, electronic devices are capable not only of acting as voltage regulators but can also furnish the field current for the generator; in other words, it is possible to have an electron tube exciter. Whether such electronic exciters possess

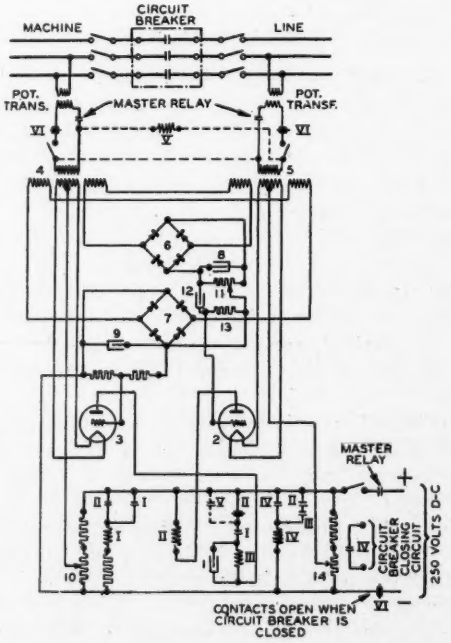


Fig. 5. The thermionic tube automatic synchronizer

advantages over present equipment sufficient to displace the latter remains to be seen.

The same condenser discharge principle used in the impulse relay and the voltage regulator just described has also been applied in an automatic synchronizer. This is a more complicated circuit than either the impulse relay or the voltage regulator and while a complete description will not be presented here, a few comments regarding the circuit shown in Fig. 5 will make clear its essential features.

It involves the use of two thermionic tubes, 2 and 3, controlling two relays II and III. These relays are of the telephone variety and so arranged that relay III operates at a fixed point in advance of synchronism, the closing characteristic being independent of the frequency difference. Relay II which is called the advance relay on the other hand is so arranged as to operate at a point in advance of synchronism proportional to the frequency difference. An interlock is provided between these two relays so that third relay, (IV) which is the energizing relay closing the main circuit breaker, is closed only if relay III is closed before relay II closes.

One of the tubes (3) is connected in series with the coil of relay III across a 250 v. d.c. supply circuit. The grid bias for this tube is supplied from the rectified beat voltage obtained from the copper oxide rectifier 7. When the phase angle between the system voltages is 180 deg. a high negative bias is, therefore, applied to the grid and the tube current consequently is zero.

As the phase angle is reduced, the negative bias is decreased and the current through relay III is increased. The system is so arranged that at a definite phase angle displacement between the system voltages the current through the coil of relay III will be high enough to operate the relay. By adjusting the potentiometer 10 the operating point of relay III can be located at any position between zero deg. and 40 deg. phase angle displacement.

The proportional advance characteristic of relay II is obtained by the action of the condenser discharge circuit consisting of condenser 12, resistor 13 and the copper oxide rectifier 6. The d.c. output voltage of the rectifier will be pulsating at a rate proportional to the frequency difference of the two systems. The voltage across the condenser 12 is equal to the output voltage of the rectifier 6 when the frequency difference is zero.

When there is a definite frequency difference between the two systems and the phase angle in changing from 180 deg. toward zero, then the voltage across the terminals of the rectifier and the voltage across condenser 12 will be decreasing but the voltage across the condenser 12 will be higher than the rectifier voltage by an amount dependent upon the time constant of the discharge circuit and the frequency difference. The discharge current from the condenser will produce a voltage drop across resistor 13 so that the potential on the grid of tube 2 becomes less negative. When the phase angle displacement between the system voltages is increasing from zero to 180 deg. the polarity of the voltage drop across the resistor is reversed. Considering the performance of the automatic synchronizer the conditions for decreasing phase angle displacement only are of interest since no relay action can take place when the phase angle displacement is increasing.

Thus, in these three applications of the condenser discharge principle, we see that all three are dependent upon the use of electron tubes. These three cases are presented here because they display the voltage measuring capabilities of the electron tube in three important control devices used in the electric generating plant. None of the devices considered have any moving parts outside of the relay contacts and all of them have definite advantages over similar forms of control using electro mechanical principles. It is not to be inferred, however, that these electronic controllers will necessarily displace other forms of controllers either immediately or in the future but they offer interesting possibilities and the chances are that we shall see more of them in use as time goes on.

Reliability—First Requirement of Steam Generating Equipment

COMMENTING on the importance of reliability of equipment, an executive of the American Engineering Co., expressed the following opinions which apply not only to stokers which were under discussion but to all steam generating equipment:

There can be no argument about the fact that reliability is the one most important requirement controlling the selection of steam generating equipment. Equipment failure necessitates the expense of shutting down one unit, and starting up another, and in addition the standby equipment is usually less efficient. Fear of equipment failure necessitates the cost of carrying banked standby equipment, ready to pick up the load.

Calculated returns on capacity and efficiency are reduced in direct proportion to the percent of outage. It is evident that the entire preliminary calculation is dependent upon the proper selection of the reliability factor, and a project that appears desirable in practice, if the wrong factor is used.

Reliability must be earned, it cannot be bought. All that can be bought is the promise of high reliability. This can be done by purchasing equipment that has previously proven itself, from an organization that has proven itself.

Many surveys show that a return of 25 to 30 per cent on the investment, is possible only when using a reliability factor of 90 per cent or higher. When considering this figure, it should be borne in mind that each week of outage reduces the reliability factor almost 2 per cent.

This report from the Longworth Steam Station of the Dayton Power & Light Co. indicates the high degree of reliability of modern steam generation equipment.

Service Time	1262 days
*Outage Time	100 days
Water Evaporated	3,055,612,230 lb.
Average Steaming Rate	100,000 lb. per hr.
Coal Burned	137,924 tons
Average Evaporation	11.15 lb. of steam per lb. of coal
Approximate Average Efficiency	84.7%

$$\text{Reliability: } \frac{1262}{1262 + 100} \times 100\% = 92.7\%$$

*Outage includes time out due to failure of any part of the complete boiler unit and periodic inspections not necessarily caused by the stoker alone.

We must confess that when it comes to the question of Electric Rates, we, as editors are as dumb as the rest of the vast majority who regularly pay our bills and believe that we are being "gypped." As a matter of fact the Public Service Company are scrupulously honest in rendering bills and we pay for only for what we use. Sometimes a rate reduction comes along and then we like to know how much we are going to save. In this article, Mr. Curry who knows all about the intricacies of "rates" tells us how we can determine the effect of such reductions simply and quickly by means of a few well chosen charts.

A Different Monthly Bill Chart

By JOSEPH J. CURRY
Bureau of Research and Valuation
New York Public Service Commission

THE EFFECT of a change in electric rates upon the individual consumer is generally explained by the assistance of charts that show unit costs or monthly bills. The importance of these curves can not be over-stated because the executive making the final decision has not time to study a detailed engineering report and may make his choice upon the basis of the general picture shown by the relatively less accurate graphs.

The customary unit cost curve, due to its hyperbolic shape, tends to deceive the eye especially where the slope of the curve approaches a vertical line. For this reason, curves based upon the monthly bill and appearing in the form of straight lines are more popular.

However, where the Hopkinson and Wright[1] types of rates are concerned, the multiplicity of charts required works against the simplicity, to which, the monthly bill curve owes its popularity. The general procedure is to have a separate chart for each selected monthly maximum demand and to show on that chart the monthly bill at all load factors from 0 to 100 per cent. It is quite obvious then, that the completeness of the general picture of the rate effect will vary with the number of charts prepared. In practice, charts are prepared for a series of typical demands depending upon the purpose of the rate; such a series may contain demands from one kilowatt to fifty kilowatts in steps or intervals of five, or from 100 to 1000 kilowatts in steps of one hundred.

Regardless of the arrangement of the demand series, all of the demands affected by the rate can not be shown. For those that are shown, the requirement of separate charts means bulky reports, the suspicion of too much detail and the not remote possibility of the rate report being hastily and half-heartedly read.

The disadvantages of the monthly bill curves may be overcome by a type of rate chart that will be explained and illustrated here. Instead of the amount of the monthly bill as a basis of comparison, the percentage difference between the monthly bills under the present and proposed rates is used.

To begin the illustration, assume the following two rates. Rate A is the present rate and is to be superseded by Rate B. It is desired to show a brief but very complete picture of the effect of Rate B upon the various consumers now served under Rate A. The rates read:

Rate A		Rate B	
First 50 KW	@ $2.00	First 50 KW	@ $1.85
Balance KW	@ 1.50	Balance KW	@ 1.25
plus			
First 1000 KWH	@ 4c	First 1000 KWH	@ 3.5c
Next 4000 KWH	@ 2c	Next 4000 KWH	@ 1.7c
Balance KWH	@ 1c	Balance KWH	@ .75c

Graphs, 1, 2, 3, and 4 show the desired picture. The limits shown for percentages, kilowatts and kilowatthours are purely arbitrary, and could be extended or condensed depending upon the magnitude of the customer's use and the extent of the rate change. The entire effect could have been shown upon one chart.

[1]The simplest system of rates which embodies both an energy charge and a demand charge is the rate system devised by Dr. John Hopkinson in 1892. Under this system the customer's bill consists of two separate portions, a demand charge and an energy charge. The demand charge is figured as the product of a certain fixed unit demand charge times the number of kw., and likewise the energy charge is the product of the unit charge times the kw-hr. consumed.

The Wright demand rate was devised by Arthur Wright of Brighton, England. This rate mentions only the kw-hr. charge and yet, it embodies the equivalent of a demand charge and sometimes a customer's charge as well. Practically all the rates on the number of rooms or floor area basis are Wright demand rates.—Editor.

As an aid in studying the graphs, some sample calculations are made in Table 1. These show the effect of Rate B by actual percentage of decrease in the last column of the table. On the graphs, the same demands and consumptions are located; cross-reference to the table is obtained by using the same identifying number that appears in the first column of Table 1.

TABLE 1
Percentage Decrease in Monthly Bills under Rate B

No.	KW	KWH	Rate A Bill	Rate B Bill	Decrease	% Decrease
1.	10	600	$ 44.00	$ 39.50	$ 4.50	10.2
2.	40	800	112.00	102.00	10.00	9.8
3.	100	2,000	235.00	207.00	28.00	13.5
4.	150	50,000	820.00	658.00	162.00	19.8

The advantages of this type of rate chart are as follows:

1. The charts are easily understood; if the demand and consumption are known, anyone with the aid of a straight-edge can determine the approximate reduction. By interpolation, the actual reduction can be read.

2. The complete range of demands is shown as compared with the relatively few demands shown when monthly bill curves are used.

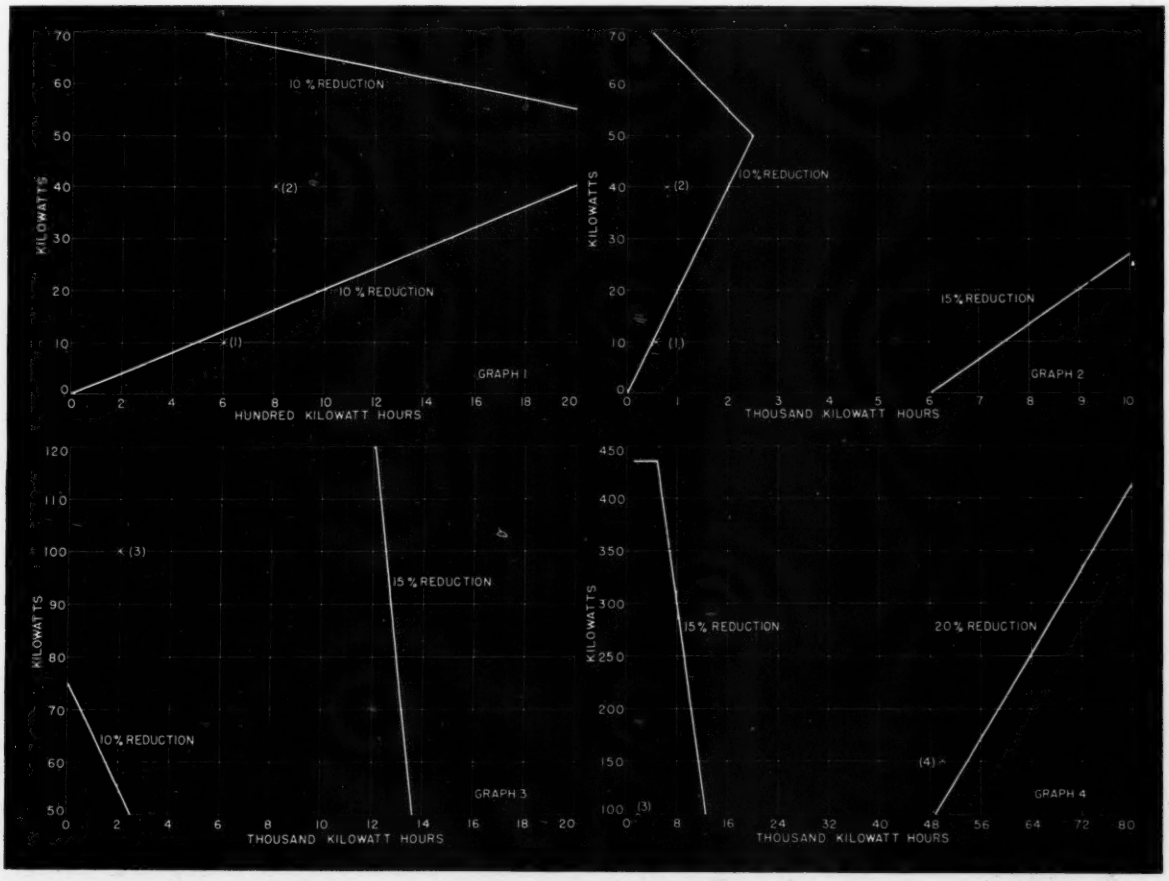
3. The number of charts needed to show a complete picture of the rate effect is greatly reduced.

4. The effect upon a particular group of customers or the effect upon the entire customer distribution may be studied, by means of these charts. It is possible to super-impose a customer distribution graph upon the chart and thus study the mass rather than the individual effect of the rate change.

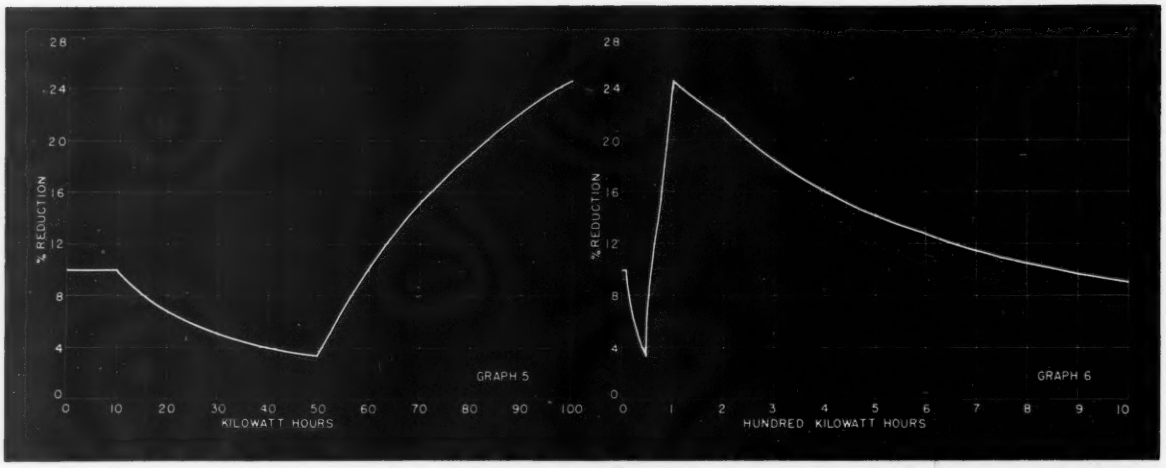
5. In the case of block energy rates the same type of chart can be used. The ordinate becomes the percentage difference in the monthly bills as maximum demand has no part in this kind of rate. Percentages of decrease can be read directly from the curve but there is no great gain in reducing the number of graphs required as but few are required under any method of plotting. Graphs 5 and 6, illustrate this application.

Derivation of Percentage Curves

The percentage curves (straight lines) are plotted from equations that are derived from the rates concerned; in this illustration, Rates A and B. These equations or rate formulae have been known for some time; their most general use has been as a short method of obtaining the amount of a monthly bill. In the explanation following, the letters D and E represent kilowatts and kilowatt hours respectively. The numerical values are all money values so the dollar sign is



Graphs 1-4. These graphs show the percentage decrease in monthly bills under rate B as compared to rate A. The per cent reduction in each case increases from left to right.



Graphs 5 and 6. These two graphs show the percentage decrease in monthly bills in the case of block energy rates, the rates being as follows:

Present Rate		Proposed Rate	
First 10 kwh.	@ $1.00	First 10 kwh.	@ $1.90
Next 90 kwh.	@ .05	Next 40 kwh.	@ .05
Next 100 kwh.	@ .03	Next 150 kwh.	@ .025
Over 200 kwh.	@ .015	Over 200 kwh.	@ .015

omitted. Table 2 shows these equations or formulae as derived from Rates A and B:

TABLE 2
Rate Formulae

	Rate A	Rate B	Range
1.	2.00D	1.85D	0 — 50 KW
2.	1.50D + 25.00	1.25D + 30.00	over 50 KW
3.	.04E	.035E	0 — 1000 KWH
4.	.02E + 20.00	.017E + 18.00	1000 — 5000 KWH
5.	.01E + 70.00	.0075E + 65.50	over 5000 KWH

For those who may be unfamiliar with the application of these formulae, the cost of 100 kw. and 10,000 kwh. will be calculated by their use. The formula applying under Rate A for demand is 1.50D + 25.00, range, over 50 kw. Substituting for D its value, 100 kw.:

$1.50 \times 100 + 25.00 = \$175.00$. Cost of Demand.

The energy formula for 10,000 kwh is .01E + 70.00, range over 5000 kwh. Substituting for E its value, 10,000 kwh.:

$.01 \times 10{,}000 + 70.00 = \$170.00$. Cost of Energy.

Total Cost = $345.00.

Within the ranges stated in Table 2, the letters D. and E represent any amount of kilowatts and kilowatt hours respectively.

Next, the formulae for Rate B are subtracted from the Rate A formulae for the corresponding ranges. As an example of this calculation, it is obvious that the difference in the first formulae in Table 2 is, 2.00D — 1.85D = .15D. The differences for all of the formulae are:

TABLE 3

	Difference in Formulae	Range
	Rates A & B	
1.	.15D	0 — 50 KW
2.	.25D — 5.00	over 50 KW
3.	.005E	0 — 1000 KWH
4.	.003E + 2.00	1000 — 5000 KWH
5.	.0025E + 4.50	over 5000 KWH

In Table 4, the differences in the formulae are combined for demand and energy.

TABLE 4
Combined Differences in Formulae

	Rates A & B	
	0 — 50 Kw.	Kwh Range
1.	.15D + .005E	0 — 1000 KWH
2.	.15D + .003E + 2.00	1000 — 5000 KWH
3.	.15D + .0025E + 4.50	over 5000 KWH
	Over 50 Kw.	
4.	.25D + .005E — 5.00	0 — 1000 KWH
5.	.25D + .003E — 3.00	1000 — 5000 KWH
6.	.25D + .0025E — .50	over 5000 KWH

The next step is to determine the percentages of the Rate A formulae that will be used in the comparison. This determination is arbitrary, being governed only by the conditions under which, for instance, a new rate proposal is made. For the purpose of this illustration it is considered that ten, fifteen, and twenty per cent, will cover all reductions made by Rate B. Table 5 shows these percentages for Rate A. Demand and energy are shown separately in Table 5; combined in Table 6 which follows immediately after Table 5.

TABLE 5

	Rate A Formulae	10%	15%	20%	Range KW
1.	2.00D	.20D	.30D	.40D	0—50
2.	1.50D+25.00	.15D+2.50	.225D+3.75	.30D+5.00	over 50
					KWH
3.	.04E	.004E	.006E	.008E	0—1000
4.	.02E+20.00	.002E+2.00	.003E+3.00	.004E+4.00	1000—5000
5.	.01E+70.00	.001E+7.00	.0015E+10.50	.002E+14.00	over 5000

TABLE 6
Percentages of Rate A Formulae Combined for Demand and Energy

	10%	15% O—50KW	20%	KWH Range
1.	.20D+.004E	.30D+.006E	.40D+.008E	0—1000
2.	.20D+.002E+2.00	.30D+.003E+ 3.00	.40D+.004E+ 4.00	1000—5000
3.	.20D+.001E+7.00	.30D+.0015E+10.50	.40D+.002E+14.00	over 5000
		Over 50KW		
4.	.15D+.004E+2.50	.225D+.006E+ 3.75	.30D+.008E+ 5.00	0—1000
5.	.15D+.002E+4.50	.225D+.003E+ 6.75	.30D+.004E+ 9.00	1000—5000
6.	.15D+.001E+9.50	.225D+.0015E+14.25	.30D+.002E+19.00	over 5000

(Continued on Page 585)

Here is a scheme as daring in conception as was Marconi's plan to first send wireless signals across the Atlantic. J. D. Ross, enthusiastic and dynamic Bonneville administrator plans to connect the great far western hydroelectric plants with the load centers in the middle west and on the eastern seaboard, using 400,000 and 750,000 v. direct current transmission lines! Such lines, he points out could be built and operated at a cost which would place the whole scheme within the bounds of sound economics and blocks of power of as great as 1,500,000 kw. could be delivered to New York City. Even with the apparatus available today, 100,000 kw. of power could be sent to Chicago over lines operating at only 150,000 v.

Shall Grand Coulee and Bonneville Send Power to New York?

IN AN ADDRESS before the Engineers' Club of Seattle on July 28, 1938, J. D. Ross, Administrator of the Bonneville project, presented a plan for connecting the great federal hydroelectric generating plant in the west and northwest to the eastern and middle western centers of population by means of transmission lines up to 3000 miles in length, extending from ocean to ocean and with cross ties from Canada to Mexico.

The implications of this scheme all but stagger the imagination and if advocated by one less an engineer than J. D. Ross might be construed as the mental aberrations of some half-baked visionary. J. D. Ross, good politician that he is, however, is no visionary, but an experienced practical electrical engineer with a strong disposition towards the scientific. Despite its startling and staggering proportions, his proposed coast to coast transmission system is based on sound reasoning and on developments which if at present incomplete, give promise of success in the comparatively near future.

It is an ambitious project that seriously considers 3000 mile transmission lines when the longest present day transmission line is less than 300 miles long, and when, according to the economics of existing lines, such 3000 mile lines would be hopelessly uneconomical even if practical.

But Mr. Ross' lines are quite different from the existing lines—he proposes to use direct current transmission instead of the alternaitng current lines in use today.

The present alternating systems would not be disturbed in the slightest. They would retain all their functions and present usefulness and the proposed direct current lines would be superposed on them. The direct current lines would act as links between all the great plants and load centers in the country.

Mr. Ross' scheme is dependent upon the further development of apparatus to convert high voltage alternating current to direct current and vice versa, specifically upon electron tube rectifiers and inverters. Such equipment for voltages on the order of 50,000 to 150,000 is available today, but for such lines as Mr. Ross has in mind much higher voltage equipment is necessary.

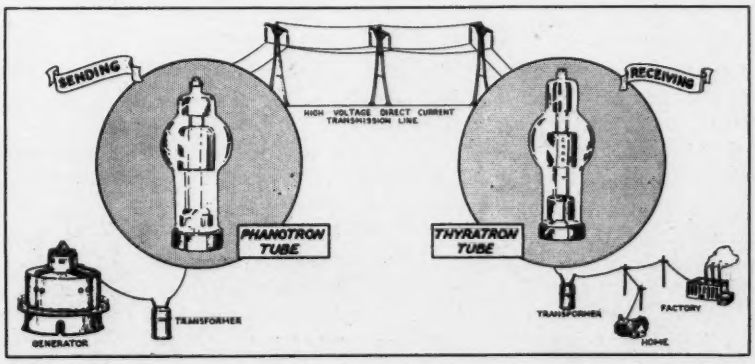


Fig. 1. This diagram shows the basic elements of the proposed high voltage direct current transmission system. At the generating end phanotron tubes convert the high tension alternating current to direct current and at the receiving end thyratron tubes invert the direct current into alternating current.

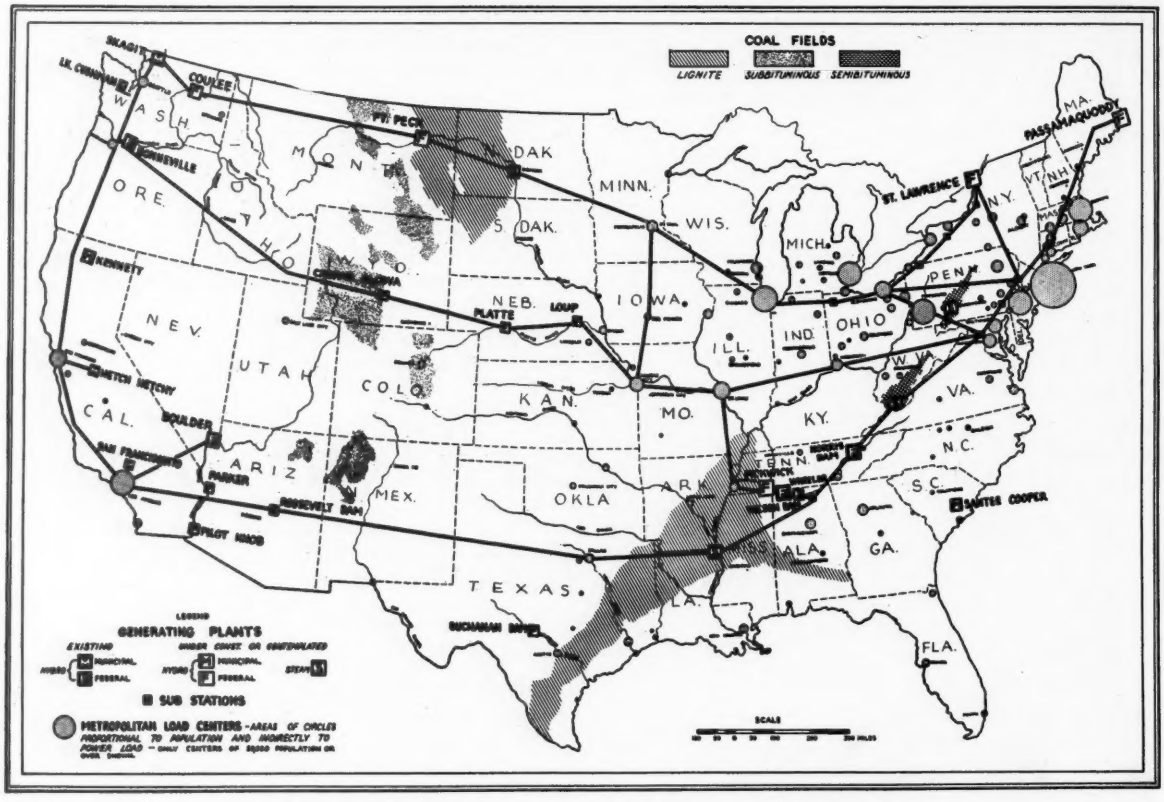


Fig. 2. Map showing proposed high voltage d.c. transmission system.

The advantages of direct current transmission over alternating current transmission need not be pointed out to electrical engineers. D. C. transmission is not hampered by the limitations of alternating current lines with their shortcomings for distances over about 300 miles. Direct current laws are very simple; the output of a line is governed only by the voltage used and by the resistance of the conductor. Therefore, by using greater voltages or larger conductors, or both, a point is reached where power is laid down thousands of miles away at the same cost now needed for hundreds of miles.

The General Electric Co. and the Allis Chalmers Co. are the pioneers in the development and production of rectifying apparatus, and are doing marvelous work.

At present direct current voltages of 100,000 v. can be produced commercially, using large glass rectifying tubes, but if desired mercury rectifiers in steel tanks can be used. With a comparatively moderate amount of research and development direct current voltages of 150,000 v. will be possible in the near future. Later progress will undoubtedly make possible 300,000 or 400,000 v., and, as necessity arises, higher voltages systems possibly will be perfected.

The electric strain on the insulation of a direct current line is only about seven-tenths of that on an alternating current line at the same voltage. Thus, a 280,000 v. alternating current line such as that now in operation from Boulder Dam to Los Angeles could have one wire removed, and could be raised, without further change, to 456,000 v. direct current between the positive and negative wire.

As an example, Mr. Ross computed the cost per kilowatt hour of a line from the Columbia River to Chicago and New York at 400,000 v. per wire, and with a loss of only 10 per cent. Two such wires of 2,500,000 circular mill copper, one negative and the other positive to ground, would transmit to Chicago 760,000 kw. at a cost of about one mill per kw-hr. for the transmission only, assuming 80 per cent load factor. This cost would be added to the price now set for Columbia power at the dam, namely, $14.50 per kilowatt-year, which is equivalent to about 2 mills at 80 per cent load factor. The rectifying tubes and apparatus would add about another half mill, so that power could be laid down in Chicago at 3½ mills per kw-hr. delivered into the Chicago distribution network.

If the voltage were raised to 750,000 there could be delivered to New York City 1,800,000 kilowatts, which is 20 per cent more than the total amount now used there. On the present New York load factor of 50 per cent, this would be 8 billion kw-hr. per year, with a cost for the 2650-mile transmission of less than 1 mill per kw-hr.

Because of the simplicity of direct current, the transmission system proposed by Mr. Ross would use wood poles instead of steel towers. The two cables of each line, one positive and one negative to ground would have the central point of the system grounded at each end. In this way each of the cables would be

an independent circuit. No current would flow in the earth as long as the loads on the two wires were equal.

Consider such a direct current line with characteristics as follows:

Length of line.....1000 miles
Voltage of line.....400,000
Maximum power loss.....10 per cent
Size of conductor.....2,500,000 cm.

It is customary to insure continuity of service that duplicate lines be used so two circuits will be necessary. Ordinarily this would require four wires, but as explained above by making one wire positive to the earth and the other negative to the earth we can use one wire for each circuit and use only two wires instead of four. This two wire system will have 800,000 v. between them, but only half that to ground.

In his analysis of costs, Mr. Ross computed the cost of a 1000 mile line as $29,280,000 or $29,280 per mile.

To those who think that the great federal projects of the Columbia and the proposed St. Lawrence plants are "white elephants," Mr. Ross said that a little study should convince them that the era of growth of the years ahead will demand not only power from these plants, but from still greater plants to be built in the future. The day is fast approaching when these plants will be built not for a local district but for all America.

A Different Monthly Bill Chart

(Continued from Page 582)

The percentages of the Rate A formulae shown in Table 6 are equated to the differences in Rate A and Rate B formulae which are shown in Table 4. The result of these calculations is the equations for Graphs 1, 2, 3, and 4; these equations are shown in Table 7.

TABLE 7

	10%	15% O—50KW	20%	KWH Range
1.	.05D=.001E			O—1000
2.	.05D=.001E			1000—5000
3.	.05D=.001E—2.50	.15D=.001E—6.00 Over 50 KW	.25D=.0005E—9.50	over 5000
4.	.10D= 7.50—.001E			O—1000
5.	.10D= 7.50—.001E	.0225D= 9.75		1000—5000
6.	.10D=10.00—.0015E	.0225D=14.75—.001E	.05D=.0005E—19.50	over 5000

To illustrate the procedure by which the equations in Table 7 were determined, the calculation will be worked for formula No. 6 under the 20% column in Table 6. This is equated to formula No. 6 in Table 4, as follows:

.30D + .002E + 19.00 = .25D + .0025E — .50
Range: Over 50kw. Over 5000kwh.

By combining like terms and transposing:

.05D = .0005E — 19.50; Formula No. 6, 20% column, Table 7.

This is shown under the 20% column in Table 7 and is the equation for the curve labeled 20%, on Graph 4. As all of these equations represent, graphically, straight lines, the substitution of two actual values for D will determine the curve. For the equation illustrated above, if 100 and 200 kilowatts respectively are substituted for D, the calculation will appear as follows:

$$.05D = .0005E - 19.50$$
$$.05 \times 100 = .0005E - 19.50$$
$$24.50 = .0005E$$
$$49{,}000 = E$$
$$.05 \times 200 = .0005E - 19.50$$
$$29.50 = .0005E$$
$$59{,}000 = E$$

These two points, D = 100, E = 49,000; D = 200, E = 59,000, are located upon Graph 4; a straight line is drawn connecting them and is extended to the limits of the graph. In a similar manner, all of the equations shown in Table 7 are transferred to the respective graphs. It will be observed that there are fewer equations or formulae in Table 7 than in the Tables 4 and 6, from which Table 7 is determined. The reason for this condition is that these final equations, in some cases, are of no practical value. For instance, if Formula No. 1 under the 20 per cent column in Table 6 is equated to Formula No. 1 in Table 4, the expression will read:

.40D + .008E = .15D + .005E, Range; O—50Kw., O –1000Kwh.

By combining like terms and transposings:

.25D + .003E = O

As this equation can have no practical significance, it is evident that the reductions under Rate B do not reach 20 per cent in this range. To avoid confusion, any final equations of this form were eliminated from Table 7.

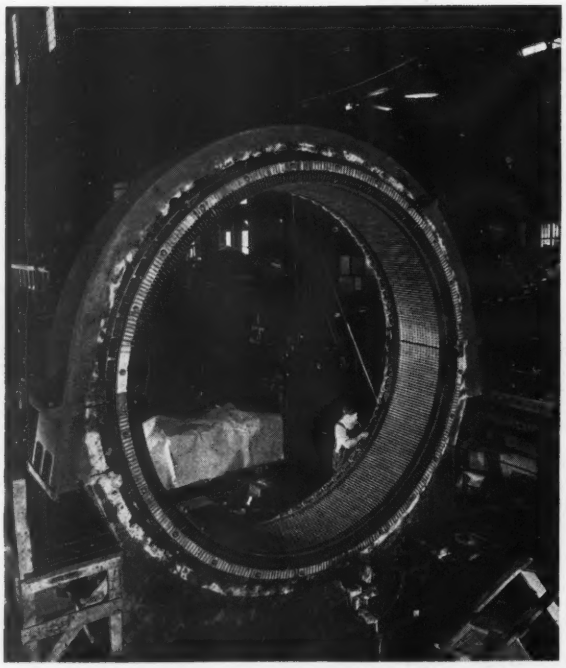
The reader may question this method of determining the points for the curves when it seems that a simple arithmetical determination of a percentage difference for two points could also determine a straight line. However, in actual practice the proposed rate would probably be higher than the present rate in certain kilowatt or kilowatt hour zones; this would complicate considerably any arithmetical determination. Also, changes in the length of kilowatt or kilowatt hour blocks would affect such an arithmetical calculation more than the formulae determination.

Saves $445 in One Year on $550 Investment

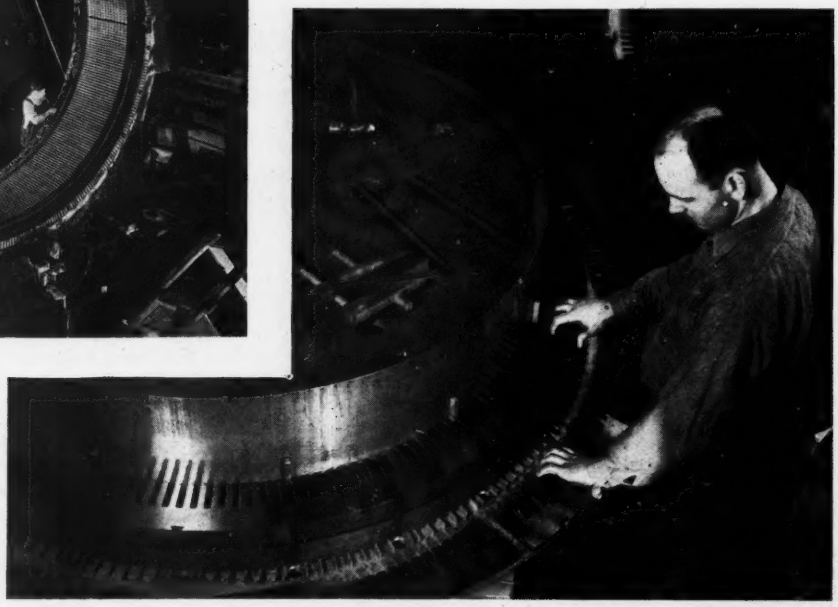
IT COST the General Ice Cream Corp. approximately $550 to install two G-E capacitors for improving the power factor of its plant at Pawtucket, R. I. Prior to this installation, low power factor has cost the General Ice Cream Corp. in the neighborhood of $181 annually under the power factor clauses of its contract with the local power company. In all probability, the corporation would have met about the same excess cost in 1937 if it had not been for the capacitor installation. Last year, however, the capacitors gave power factor from 97 to 100 per cent so that instead of paying an extra amount the General Ice Cream Corporation enjoyed power cost reductions amounting to $264. Thus, a fair estimate of the return on the investment of $550 would be $181 plus $264, or $445.

The two capacitors installed are rated 5 and 40 kv-a. The 5 kv-a. capacitor is on the line continuously, while the 40 kv-a. equipment is switched on, or off, as desired, by means of an a-c magnetic switch.

PICTURES of Engineering



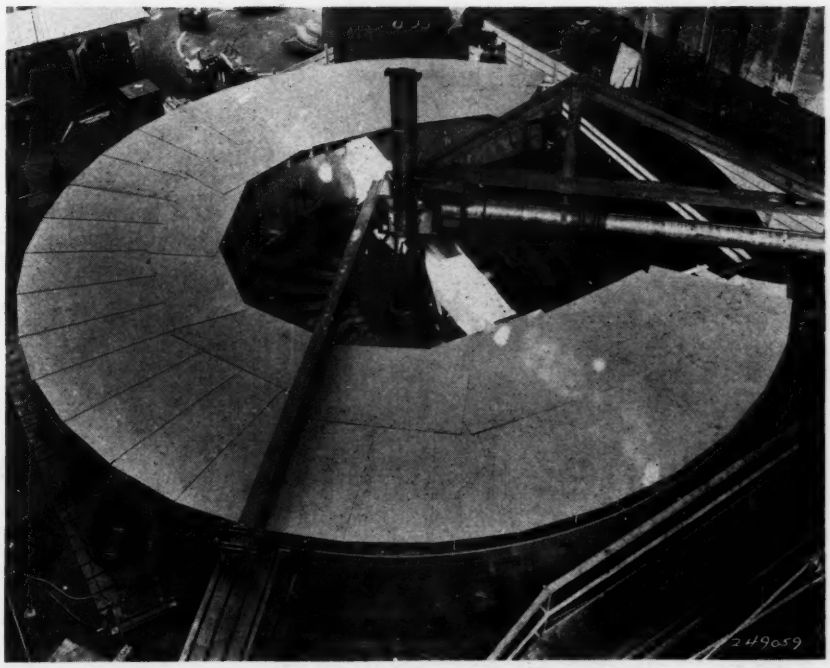
"My fingers wandered idly over the noisy keys." The picture below brings to mind the opening stanza of the "Lost Chord", but actually the man is not an organist, nor is it an organ that he is playing, though the position of his hands makes it appear as if he were fingering the keyboard of a giant pipe organ. In reality, he is stacking stator punchings against a mandrel during the construction of a large synchronous motor in General Electric's Schenectady plant. Large stators of motors and generators require many thousands of such punchings all of which have to be stacked carefully by hand.



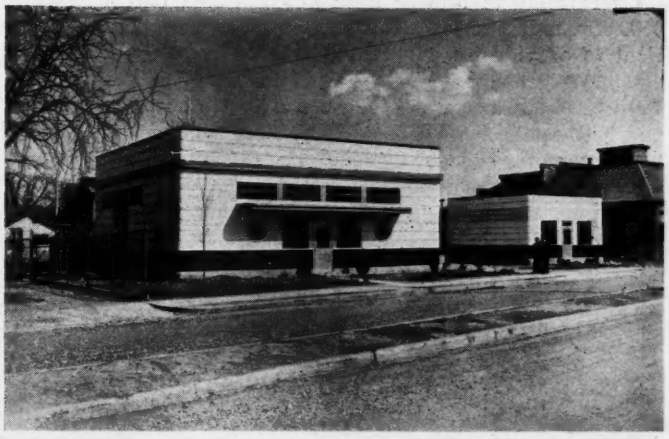
Above: They build them big at Allis-Chalmers, too. This is an immense stator for a 3500 hp. slow-speed steel mill motor being assembled in the Milwaukee shops before being delivered to the customer. The total weight of the complete unit is around 300,000 lb.

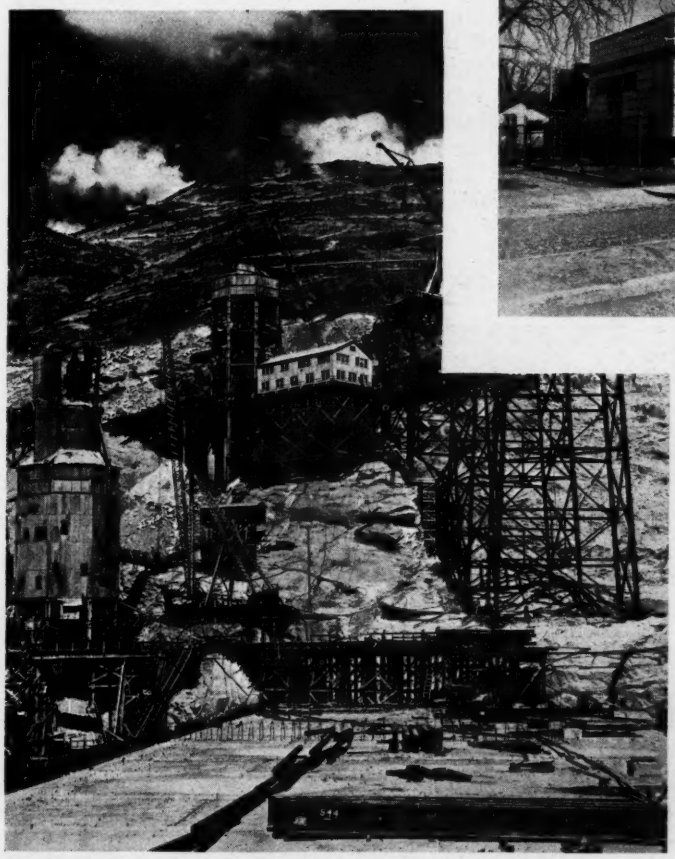
We have shown many pictures of the Grand Coulee project but in the view at the left is shown a new phase of this amazing project. These, and five other tunnels will be extended from the pumping plant at Coulee Dam, 800 ft. diagonally upward through the rock to an open canal which will carry water to a 27 mile reservoir in the Grand Coulee. Each tunnel will ultimately contain a 12 ft. steel pipe through which the output of a single pump, driven by a 65,000 hp. motor, will be delivered at the rate of 1600 cu. ft. of water per second—enough to irrigate 120,000 acres of land.

Interest



The world's largest telescope bearing recently crawled to a new world's marathon record wearing a sunbonnet and completing a 7 mile long grind in 131 working days at the Westinghouse shops in East Pittsburg. The face of this 317,000 lb. horseshoe shaped bearing had to be ground to an accuracy within five one thousandths of an inch of a perfect circle. This was difficult enough, but it was found that due to the radiation from the sun, during the day, the steel expanded as much as .0013 of an inch! So they painted the skylight and built a composition roof over the bearing, as shown in this photograph and then did their grinding only in the early hours of the morning. The job was successfully completed and the bearing shipped back to Philadelphia, where it was fabricated.





The two attractive buildings above constitute a new electrical substation recently completed at Middletown for the Middletown Gas and Electric Service Co. there. They are built with a frameless steel chassis and a porcelain enamel exterior. The 3700 sq. ft. of porcelain enamel was supplied by the Erie Enameling Co. on a base of 16 gage Armco enameling iron, a "home town" product, as it is made by the American Rolling Mill Co. of Middletown, Ohio.

Left: Parts of the base of Grand Coulee Dam have been built up to an elevation of 1000 ft. above sea level. The new trestle shown here, 180 ft. higher, will carry the output of both old mixing plants now being rebuilt high on the east side of the Columbia, out over the base of the Dam, already completed across the river. The finished dam will rise 300 feet above the present base, 120 feet above the new high trestle.

Details of the turbine installation, tests and costs as part of a $405,000 modernization program of the municipal utilities of the city of Austin, Minn. Costs cut $160,000 annually

By CARROLL L. ELLIOTT,
Superintendent
Board of W. E. G. & P. Comm.
Austin, Minn., and

JOSEPH V. EDESKUTY,*
Helmick, Edeskuty & Lutz
Minneapolis, Minn.

Turbine Room Changes at Austin

STUDIES MADE of the economic size of the new generating unit to be installed, indicated that a 3500 kw. unit with overload capacity would be sufficient to provide for expected peaks for a period of at least 8 yr. Space was provided by removing the 750 kw. unit which was of little service to the plant and had not been used since 1928, after service had been interrupted by the cyclone. The capacity of the new unit closely corresponds to the capacity of the remaining standby equipment and a further installation will be made as soon as the peak load exceeds the total standby capacity.

Inasmuch as the old turbine room floor was about 3 ft. below the boiler room floor and the turbines located on concrete foundations projecting above the floor level, the entire floor was replaced, a new concrete floor supported on steel columns and at boiler room level is finished in hard green tile of various shades and shapes. Both the old and new units and their foundations are entirely separated from this floor and the new basement floor. In the basement an asphaltum joint was laid around all foundations before pouring concrete and ½ in. space was provided around the foundations or base plates at the turbine room floor. Where gratings or small beams rest on turbine foundations, they are set on 1 in. thick rubber pads. All beams, columns and walls of the new foundation were calculated so as to have a natural period of vibration different from that of the rotating parts of the turbine.

*Engineering work for this modernization program was handled by Ralph D. Thomas & Associates, Minneapolis, Minn., with whom Joseph V. Edeskuty, the project engineer, was formerly connected. An outline of the complete program with costs was given in the article "Austin Cuts Power Costs" on page 491 of the August issue.

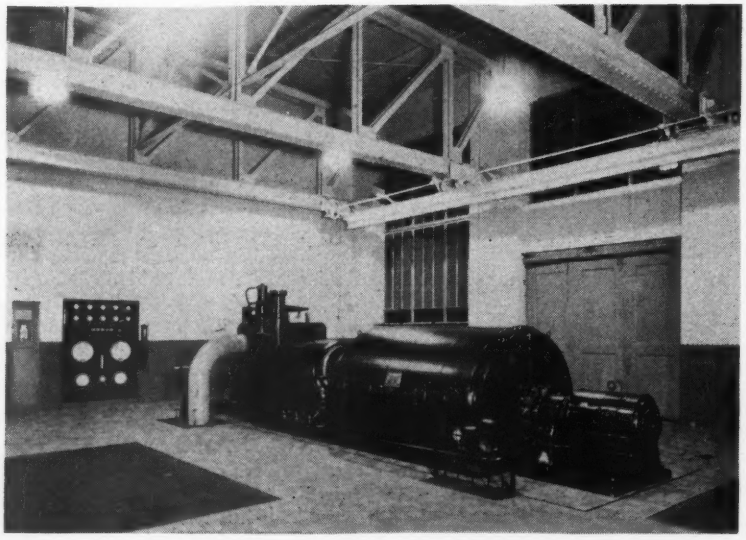


Fig. 3. In 1934 this 3500 kw. extraction condensing turbine was installed. In anticipation of the high pressure boiler installed last year this turbine was designed for 450 lb., 750 deg. F. operation although it was initially operated at the old boiler pressure of 285 lb., 650 deg. Increasing the boiler pressure will materially increase the savings

The equipment selected consisted of a 3500 kw., 3600 r.p.m., single cylinder, condensing bleeder type, Westinghouse turbine designed for a maximum throttle pressure of 450 lb., 750 deg. F., 28½ in. of vacuum and automatic extraction at 15 lb. gage. Pending the installation of a new boiler later, this unit was operated from the old boiler at a pressure of 285 lb. ga., 650 deg. F. It is still operated at low pressure and a changeover is not contemplated for a couple of years until the ratio of elecric load to heating system load increases. Change over will include new nozzle blocks from the turbines and at least one new boiler feed pump. The generator is rated at 4375 kv-a., at 0.8 p.f., 3 ph., 60 cycle, 2300 v., built with internal ventilating fans and direct connected exciter. Generator cooling is provided by a 6 pass 1220 sq. ft. generator air cooler, designed for 80 deg. F. cooling water.

This turbine was set over a Worthington 4130 sq. ft., divided water box, surface condenser, with a twin 2 stage air ejector and a large starting jet. The condenser was designed to condense 38,920 lb. of steam per hr. and produce a vacuum of 2 in. absolute when supplied with 4930 gal. of water at a temperature of 78 deg. F. Two circulating pumps were installed, one 4500 g.p.m., 18 ft. head, dual driven unit and one 3000 g.p.m., 9.5 ft. head motor driven unit. Both pumps operating in parallel will provide 5000 g.p.m. against a 24 ft. head.

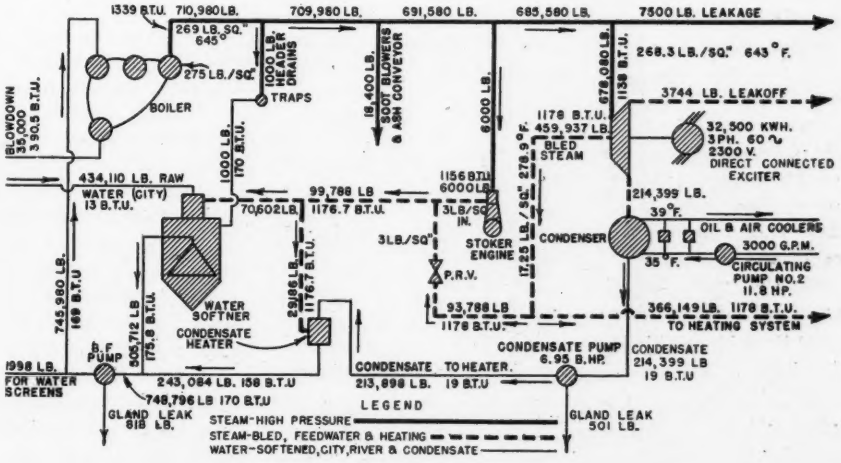


Fig. 4. Heat balance for a typical winter day, from 8 p. m. Jan. 15 to 8 p. m. Jan. 16, 1935. During the year 1934-5 the average boiler load production was 21,010 lb. per hr. The average flow to the turbine throttle was 20,213 lb. per hr. of which 10,560 was extracted at 13 lb. ga. and 9497 lb. was condensed. The average electric load was 1079 kw. and the flow to the heating system 7805 lb. per hr.

Circulating water piping to the two older generating units, originally located above the basement floor, was removed and a new system installed. Suction is taken from a cistern, located west of the turbine room, connected to the river and with a water level slightly below the basement floor. The discharge pipe from the condensers is returned under the basement floor and back to the river about 800 ft. downstream from the intake and screen house. All piping from the cistern to the turbine room floor and under the turbine room basement floor is welded Toncan iron. Discharge piping from the turbine room to the river is 30 in. concrete precast pipe.

Under normal operating conditions, the two larger units will be excited from their own direct-connected exciters but a 30 kw. General Electric steam driven exciter set was installed to serve as emergency standby for the direct connected exciters and for excitation of the 1250 kw. unit. An instrument panel set into the wall, as shown by Fig. 5, contains all the necessary operating instruments and Cochrane flow meters for indicating, recording and integrating the steam flow to the throttle and the extracted steam.

Old high pressure steam piping consisted of a 12 in. header located at the rear of the boilers, connected to a header in the turbine room with goose necks to the existing turbine throttles. This unsightly arrangement, including all reducing valves and desuperheaters, was removed and a new header system installed in the turbine room basement and connected to the boiler header. An additional boiler header was installed over the boilers and this was connected to the new turbine-room header with necessary valves so that any boiler or turbine may be taken out of service without interrupting operation.

Prior to the acceptance of the 3500 kw. unit, tests were made in strict accordance with the A.S.M.E. Power Test Code to determine the boiler efficiency, station overall efficiency, the steam consumption or water rates per kw-hr. of the new unit under various load conditions when operating straight condensing and when extracting steam for the heating system and for feed water heating. Two new tanks with long gage glasses and with quick opening valves at inlets and outlets were installed on a heater platform of the pump room and properly piped up to measure boiler feed water and turbine condensate. These tanks have been made a part of the permanent equipment and are available for future tests.

Test No. 1, extending over 24 hr., was made for the determination of the station heat rate of the new turbo-generator, production costs of electric energy and heating steam and for preparation of the station heat balance which is shown by Fig. 4. During this test in which the boiler produced 710,980 lb. of steam, the turbine 32,500 kw-hr. and the heating system used 366,149 lb. of extraction steam, the boiler efficiency,

including blowdown losses, was determined to be 64.84 per cent. After deducting the steam required for the steam jet ash conveyor and for soot blowing, this was reduced to 63.19 per cent. The turbine heat rate was 11,139 B.t.u. per kw-hr., giving a station overall heat rate of 18,121 B.t.u., or an overall thermal efficiency of 18.83 per cent. The coal rate was 1.509 lb. per kw-hr., which, with coal in the furnace of 12,009 B.t.u. per lb. and assumed to cost $5 per ton with upkeep but not including labor or overhead, gave a fuel cost of 0.377 cents per kw-hr. With an overall boiler efficiency of 80 per cent, the station heat rate would have been reduced to 14,313 B.t.u. per kw-hr., the coal rate to 1.1919 lb. per kw-hr., and the fuel cost to 0.298 cents per kw-hr.

Manufacturing cost of heating steam (for conditions existing during the 24 hr. Test No. 1, and divided between power and heating on a B.t.u. basis) was calculated on the basis of a heat liberation of 1,911,458 B.t.u. in the boiler per 1000 lb. of steam sent to the heating system. Assuming a heat loss of 30 per cent in the heating system, the heat release per 1000 lb. of steam sold was 2,730,654 B.t.u. This gave a fuel cost per 1000 lb. of steam sold of 56.84 cents. An 80 per cent overall boiler room efficiency would have changed these figures to 1,509,813 B.t.u., 2,156,876 B.t.u. and 44.90 cents, respectively.

Turbine Performance Exceeds Guarantees

Based on the annual average for the operating year 1934-35, the turbine heat rate was 13,193 B.t.u. per kw-hr., which with the then prevailing overall boiler room efficiency of 63.19 per cent gave an overall station heat rate 20,878 B.t.u. per kw-hr., a coal rate of 1.738 lb. per kw-hr. and a fuel cost of 0.435 cts. per kw-hr. Heating steam, manufacturing costs of 57.92 cts. per 1000 lb. sold on this basis would have been reduced to 45.75 cts. with 80 per cent overall boiler room efficiency.

Test No. 2 extended over 5½ hr. and was made to determine the performance of the 3500 kw. unit when generating the total electric load and supplying all the steam required for the heating system and for feed water heating by bleeding the turbine. Boiler No. 1 was supplied with water from the test tanks through centrifugal boiler feed pump No. 1 and all steam produced by this unit passed through the new header to the turbine. Boiler No. 2 generated the steam for all auxiliaries, ash conveyor and soot blower. This was piped through the old header system and was entirely disconnected from the new header supplying the turbine. During the test the steam flow to the turbine averaged 31,810 lb. per hr. at 263.2 lb. ga. and 650 deg. F. The average output of the turbine was 1655 kw., the condenser pressure was 0.5 in abs. and the steam bled at 15.1 lbs., 15.4 deg. F. superheat was 23,390 lb. At this same load, 275 lb. ga., 234 deg. F. superheat, 1.5 in. and bleeding 23,370 lb. of 15 lb. ga. saturated steam, the turbine guaranteed throttle flow was 32,750 lb. per hr. This quantity corrected to actual conditions becomes 32,589 lb. so that the actual performance was 2.39 per cent better than the guarantee.

Test No. 3, made to determine the performance of the unit when operating straight condensing, was divided into three periods: 1 hr. at minimum load, or 466 kw.; 1½ hr. at average load, or 1066 kw., 1½ hr. at maximum load of 1900 kw. The average hourly consumption was 12,890, 8407, and 21,648 lb., respectively. This ranged from 1.27 to 3.71 per cent better than guaranteed.

The hot process lime and soda water softener installed in 1928 was inadequate for a contemplated high pressure steam-generating unit, designed to operate without shut downs over long periods. None of the condensate from the heating system is returned to the boiler room and during the heating season a large portion of the boiler feed-water is therefore raw makeup taken from the city water supply.

Several problems had to be solved in order to provide the boilers with feed-water of such nature as to insure the desired operation. To permit deaeration of the feedwater and for proper chemical reactions in the sedimentation tank, the feed-water temperature must be maintained at the proper temperatures. To accomplish this, the old tray heater was removed and a jet heater was installed in its place. A separate jet heater for the turbine condensate was also installed and both heaters were provided with vent condensers for deareation. The chemical proportioning device and feeding apparatus were replaced with more modern and efficient equipment and the filtering medium was replaced with non-silicious material. Before the installation of the new steam-generating unit an automatic phosphate feeding device was added for the complete removal of the remanent hardness. A continuous blowdown system consisting of a flash tank, a heat exchanger and a sampling device was also added, to keep the concentration of solids within permissible limits in order to prevent foaming and consequent deposits in the superheater, piping and turbines. The feedwater is now maintained at a temperature of 215 deg. F. It has zero hardness, is properly deaerated, conditioned for prevention of caustic embrittlement and the boilers can be operated for at least 6 mo. periods between inspections.

Old locker and wash rooms, located on the second floor over the entrance, the office and pump room adjacent to the turbine room had been vacated for improved facilities in the new warehouse. This space was utilized for the installation of a new modern 3 ph. bus structure, with switching equipment. This room provides ample space for future additions, is light and well ventilated and permits of all necessary work under the safest possible conditions. The present 2 ph. bus and Scott connected transformer for tying the 2 ph. and 3 ph. systems in the turbine room basement, will be maintained in its old location until such times as all services of the entire system have been changed from 2 to 3 ph. current.

With the extension of the utilities, a proper system of communication between the various departments and the managing office became a necessity. For this purpose a switchboard in the office and telephones at various points throughout the plant were installed. After office hours all departmental phones are connected to the outside line.

Competent Engineers rarely endanger their reputations by "guessing." But they must know so much about so many things that it is a strong temptation to "guess" when last week's work is fast becoming next week's task. In this article Mr. Newman adds another tool to your work bag—one so easy to use that you can keep your reputation spotless by making reliable estimates in less time than it takes to guess.

MODERN TURBINES*

By
L. E. NEWMAN
Turbine Div., General Electric Co.
Lynn, Massachusetts

WHEN A PURCHASER considers buying a turbine generator set his decision is largerly influenced by the *price, shipment, performance guarantees and physical dimensions.* All of these are "dimensional" in nature whether expressed in terms of dollars, months, pounds, or feet and inches, and, as such are expressed in numbers which are related to each other. It will not be the function of this article to set absolute values of these dimensional quantities, but only how they may be expected to change when the rating is changed. Knowing how they change with rating it will be easy to estimate new "dimensions" for a new rating provided some "bench mark" is available from which departures can be made.

Unless you are familiar with the costs of building a bridge, for example, it is doubtful if you would know what increase in cost to expect when the length of a span was doubled. Does the cost of the span go up twice, three times, or only a few per cent when its length is doubled? And does it take twice as long to build, or perhaps no longer time to build? If you are familiar with the construction of bridges you know the answers to these questions, just as an experienced turbine engineer knows what changes to expect when he increases or decreases the rating of a turbine generator set.

Others not in such close contact with turbines frequently request a multitude of propositions from turbine manufacturers and cull from these many proposals the one best suited to their needs. Usually these many proposals could be boiled down to one basic machine, or perhaps one basic machine with an alternate, IF THE PROSPECTIVE BUYER KNEW WHAT HAPPENED WHEN HE CHANGED DIFFERENT CONDITIONS. From one given proposal used as a "bench mark," a turbine specialist can usually make accurate estimates of each of the dimensional quantities when changing rating, steam conditions, or whatnot. With the charts included in this article an engineer with far less turbine experience can do much that otherwise could be done only by engineers long in direct contact with similar problems.

Discussion of this can be divided into two parts; first, an explanation of corrections to apply when changing the rating of a turbine generator set, maintaining other conditions constant; and, second, corrections to apply when changing steam conditions at constant rating. In this article only the question of change in rating will be discussed. In a later article the second question will be answered.

In this, as in previous articles, the data is based on standard 50 or 60 cycle direct connected turbine generator sets rated 500 to 7500 kw., sets commonly used by industrial manufacturers. The charts included in this article are: Fig. 1, Price Correction Chart; Fig. 2, Steam Rate Correction Chart; Fig. 3, Shipment Chart; Fig. 4, Length Correction Chart; Fig. 5, Weight Correction Chart. With the exception of the shipment chart, each chart gives the correction to make to one variable when the rating is changed.

An easy way to understand the use of the charts, and why the variables change as they do, is to work through a typical example. Let's assume for this example that a proposal has been obtained from a turbine manufacturer on a 2000 kw. condensing set, but, that there is some uncertainty as to whether the liberal policy of buying a 2500 kw. set or a policy of minimum investment furthered by installing a 1500

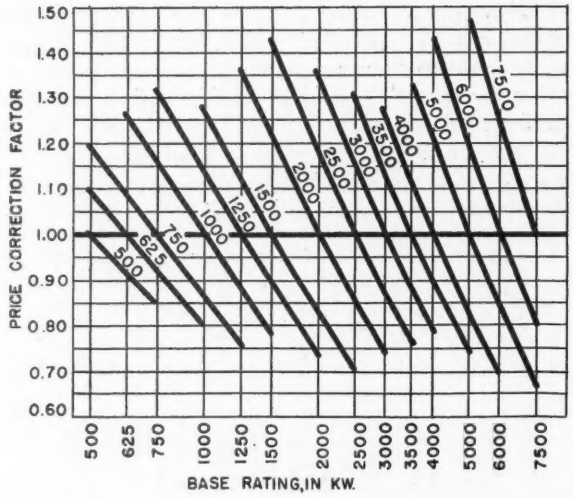


Fig. 1. Price correction chart for change in rating with other conditions constant. Figures on curves are ratings, in kw., above or below the base rating

Example

Problem:

To determine the price of a 1500 kw. and a 2500 kw. turbine generator set designed for the same conditions as a 2000 kw. set, the price of which is known. (Assume for this example that the 2000 kw. set has a price of $55,000)

Solution:

Using 2000 kw. as the base rating the prices of the other two sets based on factors read from this chart will be:

1500 kw. = 55,000 × .825 = $45,400
2500 kw. = 55,000 × 1.175 = $64,600

kw. set should be followed. Using the proposal on the 2000 kw. turbine generator as a bench mark a few minutes' time is all that is necessary in order to quickly estimate what to expect for the alternative choices. Then,

BENCH MARK (Assumed values)

Rating, 2000 kw.
Price, $55,000
Shipment, 6 mo.
Full-load steam rate, 12 lb. per kw. hr.
Overall length, 24 ft.
Net weight, 60,000 lb.

From this bench mark and using the charts these tabulations may be obtained:

	2000 KW. BENCH MARK	1500 KW RATING CORRECTION FACTOR	CORRECTED RESULT
Price	$55,000	0.825	$45,400
Shipment .	6 mo.	—	6 mo.
Steam Rate	12 lb. per kw-hr.	1.029	12.35 lb. per kw-hr.
Length ...	24 ft.	0.924	22.2 ft.
Weight ...	60,000 lb.	0.810	48,600 lb.

	2000 KW. BENCH MARK	2500 KW. RATING CORRECTION FACTOR	CORRECTED RESULT
Price	$55,000	1.175	$64,600
Shipment .	6 mo.	—	6 mo.
Steam Rate	12 lb. per kw-hr.	.98	11.76 lb. per kw-hr.
Length ...	24 ft.	1.058	25.4 ft.
Weight ...	60,000 lb.	1.18	70,800 lb.

An explanation of why each variable changes as it does will broaden our understanding of turbines. But before that, let's clearly understand that these charts are based on changing only the rating, and holding all of the other conditions constant. If the error were made of trying to correct a proposal on a 2000 kw. turbine designed for an initial pressure of 400 lb. to a 2500 kw. turbine designed for 600 lb. every correction factor would be wrong. The price would be higher than the correction indicated, the steam rate lower, the length longer, and the weight greater. But the charts will give close estimates for any type of turbine be it made by one manufacturer or another, be it condensing, non-condensing, or extraction, provided that the only change from the bench mark is the change in rating.

It will be noted from the price correction chart, Fig. 1, that each kilowatt of rating costs less as the rating is increased. When the initial rating is low, price per kilowatt of rating decreases rapidly with an increase in rating. Then, as might be expected, decreases less rapidly as the rating is increased until finally the price per kilowatt becomes practically constant regardless of rating.

Shipment, as shown in Fig. 3, will range from an average of 4 mo. for a 500 kw. set when business activity is low, to 9 mo. for a 7500 kw. set when business activity is high. However there is more to be said

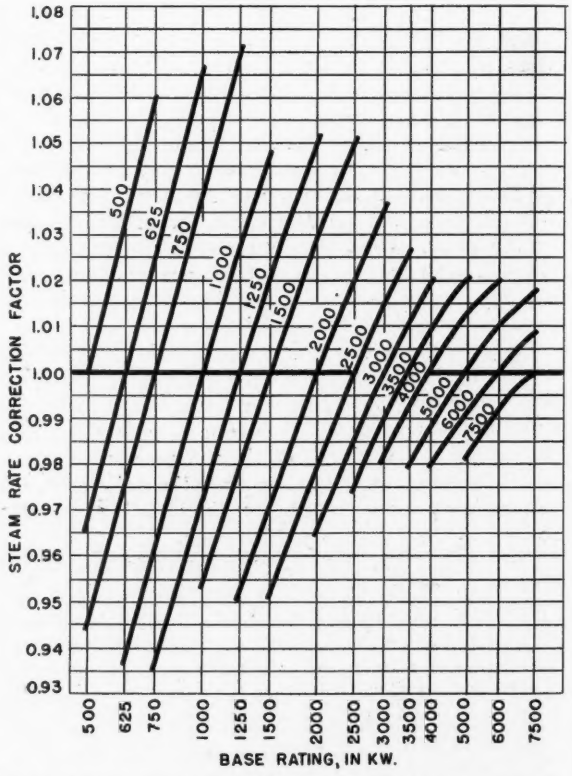


Fig. 2. Full-load steam rate correction chart for change in rating with constant steam conditions. Figures on curves are ratings, in kw., above or below the base rating

Example

Problem:

To determine the full-load steam rate of a 1500 kw. and a 2500 kw. turbine generator set at the same steam conditions of a 2000 kw. set, the performance of which is known. (Assume S.R. of 2000 kw. = 12 lb. per kw-hr.)

Solution:

Using 2000 kw. as the base rating the full-load steam rate of a turbine generator set rated

1500 kw. = 12 × 1.029 = 12.35
2500 kw. = 12 × 0.98 = 11.76

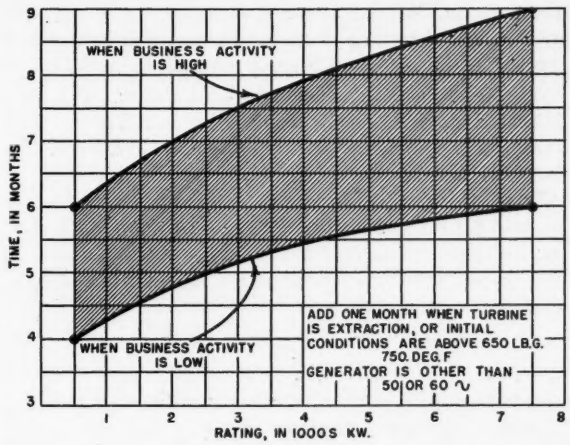

WHEN BUSINESS ACTIVITY IS HIGH
WHEN BUSINESS ACTIVITY IS LOW
ADD ONE MONTH WHEN TURBINE IS EXTRACTION, OR INITIAL CONDITIONS ARE ABOVE 650 LB.G. 750 DEG.F
GENERATOR IS OTHER THAN 50 OR 60 ∿
TIME, IN MONTHS
RATING, IN 1000S KW.

Fig. 3. Approximate length of time required to manufacture turbine generator sets

than this about shipment of turbines, each of which is individually tailored to meet the requirements of a specific application. The manufacture of a turbine generator set involves a great many operations some of which may be carried on in parallel but many of which must be done in series. Generally these operations which must be done in series require lengths of time to complete about in accordance with the accompanying shipping table.

If a manufacturer estimates that shipment can be made within 6 mo. from the date a complete release of manufacture is given, a fairly good idea can be obtained of when the different operations will be completed during the manufacturing period. Thus, 6 mo. is equal to 26 wk. so most of the engineering and drafting will be completed at the expiration of something over 5 wk. Castings and forgings of limiting parts will be obtained and machining started within about 10 wk. of the date work is released. From the same table it is possible to estimate what delay in shipment to expect should there be a request to change the design of some part after manufacture has been under way for some time.

SHIPPING TABLE

STEP IN MANUFACTURE	TIME TO COMPLETE, IN % OF SHIPPING ESTIMATE
Engineering and Drafting	20
Castings and annealing, forging and heat treating	20
Machining	25
Assembly	20
Test	10
Preparing for shipment	5
	100

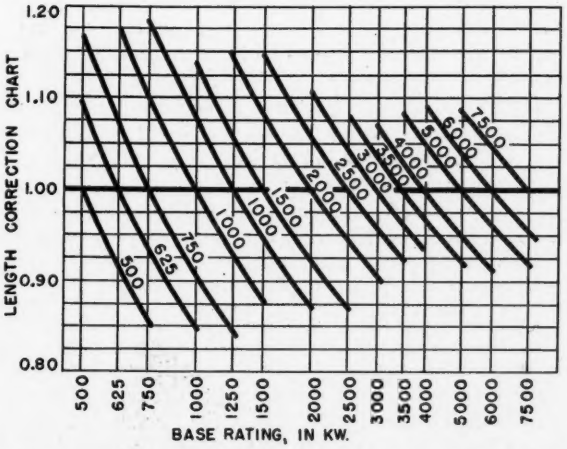


Fig. 4. Length correction chart for change in rating with other conditions constant. Figures on curves are ratings, in kw., above or below the base rating

Example

Problem:

To determine the length of a 1500 kw. and a 2500 kw. turbine generator set designed for the same conditions as a 2000 kw. set, the length of which is known. (Assume, for this example, that the 2000 kw. set has a length of 24 ft.)

Solution:

Using 2000 kw. as the base rating the lengths of the other two sets based on factors read from this chart will be:

1500 kw. = 24 × .924 = 22.2 ft.
2500 kw. = 24 × 1.058 = 25.4 ft.

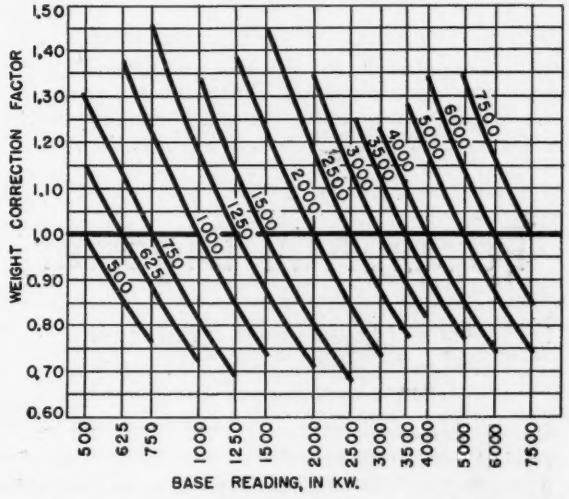


Fig. 5. Weight correction chart for change in rating with other conditions constant. Figures on curves are ratings, in kw., above or below the base rating

Example

Problem:

To determine the weight of a 1500 kw. and a 2500 kw. turbine generator set designed for the same conditions as a 2000 kw. set, the weight of which is known. (Assume, for this example, that the 2000 kw. set has a weight of 60,000 lb.)

Solution:

Using 2000 kw. as the base rating the weights of the other two sets based on factors read from this chart will be:

1500 kw. = 60,000 × .81 = 48,600 lb.
2500 kw. = 60,000 × 1.18 = 70,800 lb.

The steam rate correction chart, Fig. 2, only gives the correction to be applied to the full-load steam rate for a change in rating. How about the steam rates at other loads? They are easily obtained by assuming that the part load steam rates at the new rating will have the same relation to the full load steam rate as the part load steam rates of the bench mark rating have to their full load steam rate (S. R.). Thus,

½ load S.R. of new rating =

$$\frac{\text{½ load S.R. of bench mark}}{\text{Full load S.R. of bench mark}} \times \text{Full load S.R. of new rating}$$

Note that the part load steam rates of a new rating are based on loads at the same *percentage* of the new

full load rating, and not the same kilowatt loads. Actually, partial load steam rates will improve with increase in rating, so this assumption should be made only for a change from one rating to the next higher or lower, and not extended to a jump of two ratings.

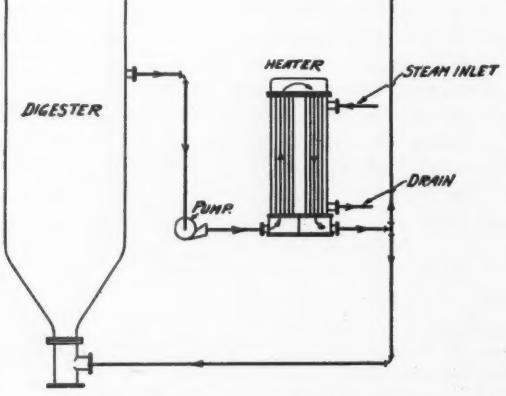
Little need be said about change in length or weight with increase or decrease in rating. But here again it must be remembered that the charts only take into account the increase or decrease in length and weight when the rating is changed but other conditions held constant. An extraction turbine is longer than a non-extraction turbine, for example, but if the type of turbine and steam conditions stay the same the chart will give fairly close estimates of what to expect for a larger or smaller base rating relative to some bench mark.

In next month's article interesting methods will be described for finding out what happens when the rating is held constant but other conditions varied. Then, when conditions require it, the methods given in the two articles can be combined and accurate estimates made for all manner of changes in conditions.

Paper Mill Digester

Indirect heaters used in the newer sulphate mills have many advantages over the old direct type

PART of the paper making process involves cooking the pulp with chemicals, in a cylindrical vessel or digester. Conventional practice involves the injection of high pressure steam directly into the digester so as to maintain a temperature of from 340 to 350 deg. F. The newer sulphate mills, however, are using an indirect method of heating, as shown by the drawing, illustrating the application of Foster Wheeler heaters to the new mill of the Crossett Lumber Co. Chemicals or liquors are heated in an external closed heater and circulated by means of a small pump.



Arrangement of an indirect heater and forced circulation as used in a paper mill digester

Indirect heating has several advantages. The pulp is heated more uniformly and the improved circulation shortens the cooking period. Steam used for heating is reclaimed as pure condensate and the liquor is not diluted, this decreasing the chemical consumption to a certain extent and resulting in saving steam used later in the concentration of the black or waste liquor. It is also possible to use low pressure steam during the first part of the cooking.

Series Capacitor Solves a High-Current Power Factor Problem

THE USE OF SHUNT capacitors to raise the power factor in inductive loads is a common practice. In some cases, however, the actual load itself is a relatively high power factor, but the overall power factor of the local circuit may be low because of the reactance of the circuit itself.

The specific instance in mind—though the problem appears in many other forms—is for the improvement of the power factor of a heavy, resistance furnace load. Such furnaces require at times about 40,000 amp. at approximately 40 v. Specially designed furnace transformers with load type tap changers are used to supply the load. Even with interlaced leads the inductance of the low-voltage buses would be sufficient with this river of current to cause a reactive drop in the buses of almost twice the voltage drop across the furnace itself. The resulting overall power factor would be about 44 per cent.

This would necessitate a transformer rating more than double the kilowatts required for the load. Here the series capacitor makes an ideal method of improving the overall power factor, because it may be inserted in series with the load, thus directly cancelling the reactive drop in the circuit for all values of operating current through the furnace, giving automatic control and unity power factor at all times. A shunt capacitor would have involved the use of step type variations in corrective kv-a., and the necessity of manual control for each value of furnace current to keep the power factor between the desired limits.

A 40,000 amp. capacitor would clearly have been impractical, so that a series transformer connected capacitor was necessary. This made it possible to use 2300 v. capacitor units connected to the secondary side of the series transformer units, the primary of which was connected in series with the furnace. In addition the characteristics of the series transformer were made such as to limit definitely the current which might be obtained under short circuit. (From the Westinghouse Engineering Progress Report.)

REFRIGERATING chambers aboard ships are being lined with sheets of monel in order to assure cleanliness and freedom from rusting, pitting and corrosion by condensed moisture from meats and foodstuffs.

Heaters, along with other equipment, are not always installed right and operators often put up with the poor performance and inconvenience for years. Here is what one enterprising engineer did to correct long standing source of trouble. It's not what he would do if it could be torn out and put back new but it offers a practical solution of the trouble with the minimum expenditure of labor and materials.

Feedwater Heaters Will Work

By JULIUS BRODSKY

FOR SOME unexplained reason it is not unusual to find equipment in power plants incorrectly installed and yet has been operated over a long period of time under adverse conditions, when, a little common sense with a few simple inexpensive changes might convert it from an operating nuisance to an efficient piece of apparatus. This is illustrated by the accompanying sketch of a feedwater heater and condensate-return tank as installed in one plant. With the exception of some piping connections, not necessary to illustrate this story, it duplicates the original blue prints as they left the consulting engineer's office.

This plant has been in operation many years with the exhaust steam pressure at 4 to 5 lb. ga. Early operating experiences had shown that it was impossible to operate with this pressure in the heater, consequently the 10-in. valve in the line from the main exhaust was kept closed so only the exhaust steam that came from the pumps through the 5-in. line was allowed to enter the heater. Under these conditions the feedwater was always comparatively cool.

Later attempts to raise the feedwater temperature by regulating the steam flow to the heater by means of the 10-in. gate valve did not prove successful, and it was the unanimous opinion that the heater was no good and should be replaced. A little study, however, showed that with a few minor changes it could be made to function correctly and that all operating difficulties previously encountered eliminated.

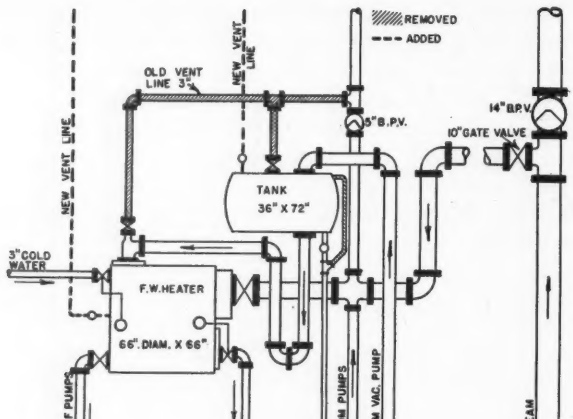
The heater showed it to be no different from thousands of others and is capable of successful operation. The only function of the tank shown in position immediately above the heater is to receive the condensate or returns from the heating system and allow the air that is entrained in the water to escape to the atmosphere. The air-free water then passes on to the heater and the air escapes by way of the 3-in. vent line, or, through the overflow line. Since the exhaust steam pressure may be as high as 5 lb., this pressure will exist in the heater when the 10-in. valve from the main exhaust line is open. Some means had to be provided so that the water in the tank, which is under atmospheric pressure, will flow to the heater.

In most installations the tank is placed sufficiently high above the heater so that there will be a head of water great enough to overcome the pressure in the heater and allow the water to flow by gravity from the tank to the heater, in this case a minimum height of 12 and preferably 15 ft. would be necessary. An alternate method is to locate the tank at floor level and use a booster pump to force the water into the heater, while still a third method is to make use of a hydro-pneumatic, or, closed pressure tank, allowing a continuous escape of air but maintaining in the tank at all times a pressure slightly greater than that in the heater.

It was apparent that the minimum amount of labor and material would be required if the third method was adopted. The tank was retained in the same location but converted to a pressure tank. The 3-in. vent lines from the heater and tank and the overflow line from the tank were removed and the openings plugged, small vent lines were then attached to the heater and tank as indicated.

When the heater was restored to service it was possible to maintain full exhaust pressure in the heater, the feedwater temperature rose to and stayed continuously at 220 deg. F. and no further operating difficulties were experienced.

The above job was done by a mechanic and a helper in a day's time and since the small amount of pipe and



This feedwater heater installation, which caused trouble for 17 yr., was fixed up at a cost of $15 by removing the piping shown crosshatched and adding the two vent lines shown by heavy dashes

fittings needed were on hand there was no expense for material. The total cost of converting this installation from an operating nuisance to an efficient piece of apparatus was $15, an insignificant sum compared to the expense involved in the purchase and installation of a new heater.

Industrial Efficiencies Advance with Redesigned Equipment

A SURVEY conducted for the Electric Welding Section of the National Electrical Manufacturers' Association emphasizes the new trends of application of the metallic arc welding process and reveals that impressive advances in the efficiencies of industrial equipment have originated in new designs that are predicated on arc welded construction. That is, the welding arc has ceased to be an incidental tool, restricted to a limited field of minor assemblies, and has acquired the status of an essential fabricating method on the modernized structures that are responsible for numerous long range economies in the heavy industries.

It required some 40 yr. of intense study to make this process suitable for assembling structures in which safety and dependability is of vital importance. The great obstacle was that liquid steel while passing through the arc picked up harmful elements from the atmosphere with the result that the weld zone did not equal the full strength of the adjacent parent metal. Science eventually overcame this obstacle by surrounding the welding wire with heavy coating which would melt simultaneously with the wire and prevent the atmosphere from reaching the weld metal. It then became possible to deposit weld metal which would be 100 per cent as sound and strong as the material which it joined. In fact, the weld zone can readily be made stronger if it is desired. Thanks to this refinement in the process, the designing engineer can figure his weld as being the strongest portion of his structure instead of being a zone of reduced strength as in the early days of the art. This development is the real basis of important design trends that were noted in the course of the survey mentioned above. It seems to have been the case that research engineers in several fields could visualize new and better ways of doing things, but had not been able to put their ideas into practice because there seemed to be no way to fabricate satisfactorily, the new types of equipment that would be necessary.

The petroleum industry, which above all others requires equipment of unfailing safety and dependability, seems to have taken the lead in the adoption of arc welded construction. The petroleum industry started to use welded cracking stills about 1925 and there resulted immediately a program of advancing not only the temperatures and pressures used in cracking but also volume capacity of refinery units. Within 5 or 6 yr. it was estimated that about 1500 welded pressure vessels were installed by refineries; in the next five year period about 7000 more. The effect on the economics of refining has been to increase the productive efficiency that is the proportion of gasoline recovered from crude, by about 50 per cent.

Excavating and earth moving machinery have had to grow up in order to match the dimensions of the highway programs that are with us today; and finally these massive machines grew so unwieldly they had to go on a welding diet, Tons of weight were taken off the structural parts, and added to the pay loads by this process of redesign.

Power plants have advanced efficiencies through redesign on a scale that in some ways is comparable to what has been done in the oil industry. Higher temperatures and higher pressures in steam plants are developing up to 90 per cent more electrical power from a ton of coal than the average plant of older design, and although many devices have contributed to this progress the key factor has been the possibility of arc welding the high pressure boiler drums, and the high pressure piping systems for the modern plant.

The composite result is a new order of achievement in production, a movement which has carried far enough to establish itself soundly and firmly. And the welding enthusiast who preaches the principle of redesign is only prescribing that which built up a flourishing new industry, because many of these big things developed as a result of the redesign of the wire used in arc welding.

A MINER'S ELECRTICAL cap lamp has been developed, which now gives the subterranean worker as high a standard of illumination on his work as that customarily provided for similar work above surface. Energy for the lamp is stored in nickel-iron-alkaline storage batteries, the most important component of which is a nickel flake said to be as light and sparkling as snow. Enclosed in a monel container, the portable battery stores enough electrical energy to light the lamp for 10 to 12 hr. before recharging, providing 5 to 20 foot-candles of illumination at the center of the miner's field of vision.

'Round About
with the Engineering Editor

Mahoningside Station of The O. P. S. Co. at Warrent, Ohio, is being topped . . . A 300,000 lb. B. & W. special three drum, pulverized coal fired boiler will supply steam for an 825 lb., 825 deg. F., 8570 kv-a. Westinghouse turbine which in turn will exhaust to two 200 lb., 15,625 kv-a. Westinghouse units just rebuilt . . . 16,000 sq. ft. Worthington condensers replace the old jet condensers . . . Three B. & W. mills and five burners . . . Pratt & Daniels induced draft fan at the base of a new 8 by 250 ft. stack . . . 69,200 c.f.m. forced draft Sturtevant fan . . . One 280,000 lb. per hr. Cochrane deaerator . . . Griscom-Russell stage heater on high side of two Worthington boiler feed pumps; one turbine, one dual drive . . . John Collister is Production Engineer, C. H. Byers is Station Superintendent . . .

* * *

Twenty-eight hydrogen cooled generators have been ordered and five are already in service at: Miller's Ford, Logan, State Line, Waterside and Essex.

* * *

Andy Kramer of the Wooden Shoes and Mountain Goat proclivities, disguised as the Big Bad Wolf for the edification of fellow Canadian Alpine Clubers (and his own protection) in the Canadian

Rockies . . . Each year he takes time off from electrical editoring to make the pilgrimage and waggle a mean ice axe . . . He passed up a first ascent this year to perfect his technique and break out as a full fledged radio star on a national hookup . . . If you heard the Canadian Broadcasting Co. mountain climbing program, you heard Andy Bill's crampons crunching over the ice with the microphone at his heels . . . In case you don't know, crampons are the iron spikes mountain climbers affect over their ballet slippers when they want to gambol over the ice yet don't feel quite up to risking a sideslip into a crevasse. . . .

STEAM TURBINES, on the hoof, sell for about a dollar a pound . . . If you forget what yours cost you can check it piecemeal on the bathroom scales probably with no more mental and physical effort than needed to interpret an accountant's report . . . Robert N. Tucker, superintendent of the municipal light plant at Columbus, O., is putting the finishing touches on a new 450 lb., 200,000 lb. per hr. boiler . . . The paper industry is booming too and F. H. Bither, general superintendent of the American Box Board Co., at Grand Rapids, Mich., has a new 200 lb., 100,000 lb. per hr. Edge Moor boiler with a Stowe stoker and Hagan control coming up . . . C. R. Seaborne, general superintendent, Thilmany Pulp & Paper Co., Kaukauna, Wis., put a new 1000 hp., 225 lb., 63,000 lb. pr. hr. pulverized coal fired Wickes boiler in service this spring.

Lee M. Nelson, formerly general superintendent of the City Water and Light Dept. at Hastings, Nebr., is the new superintendent of the Municipal station at Rochester, Minn. . . . L. A. Cowles, former superintendent, is field engineer for Burlingame & Hitchcock, consulting engineers for the station . . . With the neighboring city of Austin, Rochester shares the honor of having the first of the new water cooled stokers with the cooling tubes tied directly into the boiler circulation and both furnaces are designed for coal and gas . . . Al Hansen at Hibbing, Minn., recently started up a 90,000 lb. per hr. Riley boiler fired by a Westinghouse stoker.

Minnesota municipal plants are expanding so rapidly it is difficult to keep track of them . . . E. T. Kleve, general superintendent at Wilmar, expects to have a new 2000 kw. G.E. turbine, 400 lb. Foster Wheeler boiler with Cash control and a Lille-Hoffman cooling tower in service by September . . . Mora recently purchased a Worthington 500 hp. Diesel . . . Cambridge and Sherburn are considering new plants . . . N. D. Miller, general manager at Worthington tells us that Chief Engineer K. R. Duncan will soon have a new boiler to match the 1250 kw. G.E. turbine installed 2 yrs. ago . . . Superintendent A. Moline at Blue Earth is putting the finishing touches on a new 2500 kw. Westinghouse turbine to help Fritz Liljedahl, Chief Engineer, pull the ever increasing load . . . John Ulrich at New Ulm is making way for a new turbine now that his new boiler is in service . . . At Fairmont, Chris. Rehm recently unloaded a new 2500 kw. Westinghouse unit because his load this year is running 10 to 27 per cent over corresponding periods last year.

The 500 kw. unit removed from Fairmont, to make way for the new turbine, will turn out kilowatts for Master Mechanic Bill Kraschnewski of the Rodjis Lumber & Veneer Co. of Marshfield, Wis. . . . Here wood imported from all over the world is made into the country's finest veneer and a trip through the panelled offices with President Louis Korth is like a tour around the world . . . At the Marshfield municipal plant, Geo. Marvin, superintendent, is installing a second C. E. boiler . . . With the load up about 20 per cent over last year Fred Snyder of Owatonna, Minn., has a new 2500 kw. Westinghouse turbine and looks forward to an increase in boiler capacity in the near future . . . Rumor says Oscar Mayer will increase the boiler capacity at the Madison, Wis., packing plant.

G. G. Post, V. P. in charge of P. P. Tmer & L. Co., quotes with gusto the latest statistics on Port Washington's ever changing list of World's records: 1937 production 387,914,490 kw-hr. average 10,835 B.t.u. per kw-hr. net, down from 10,954 B.t.u. for 1936: May 2, 1937, to May 2, 1938, availability 94.75 per cent, running time 91.8 per cent . . . An unusually good hydro year in Wisconsin is robbing steam plants of load, Port Washington included, so a no load week end shut down the first week in April ended 4176 hr. of continuous operation but the station operated 4569 hr. between inspection periods from October 11, 1937, to April 23, 1938 . . . Harry A. Shaver, engineer in charge, has the week end problem down to a science—fuel shut off at 10 P. M. Saturday—turbine tripped when the pressure drops to 500 lb.—one burner started at 3 A. M. Monday—begin picking up load slowly at 5 A. M.

Richard H. Morris

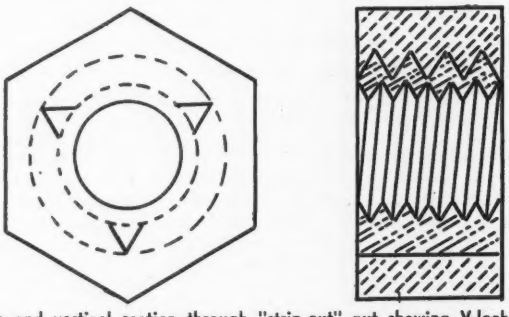
Readers' Conference

These pages are open to readers for the presentation or discussion of any timely power plant topic. The Editors invite your participation.

Strip-out Nuts for Pressure Relief

WHERE low pressure fittings are used on the suction side of pump installations intended for high discharge pressures, occasional damage results through the release of high pressure fluid against a closed gate in the suction side, as for instance where bypasses are used to permit gradual pressure build-up under load. Although most pipelines carrying high pressures are provided with some type of automatic—either spring or dead-weight loaded—and most plunger pumps are also factory equipped with spring-loaded relief valves. It sometimes happens automatic relief valves can not or do not function in time to save the suction piping, or the bypassed pressure, although far exceeding the nominal working stress of the suction line, does not reach the set point for the high-pressure relief fitting.

In one pump station where the end flange on the suction header was equipped with a small spring-loaded relief valve a surge shattered the flange against the concrete wall of the pit. After much time spent in trying to devise a grooved or cross-scored flange which would break within a limit of 20 per cent of the desired pressure increase, the experimentation was changed over to consider the means of holding the gasketed flange in place.



Plan and vertical section through "strip-out" nut showing V-lock to prevent turning and the method of supporting the bolt solely by type-metal threads when under load

Resulting tests showed that the eight ¾ in. nuts used to hold the blind flange in place could be worked over and used as "strip-out" nuts, with a yield point varying within plus or minus five per cent of the desired pressure. Nuts, of the usual cold-pressed, semi-finished type provided for normal flange connections, were drilled out and tapped for ⅞ in. bolt threads and then cut out by three 60 deg. cuts as shown in the sketch. This done, the nuts were poured full of type metal, used because of the relatively slight shrinkage on cooling. This center of type metal was then drilled and tapped for the original ¾ in. threads, and the nuts replaced.

Tested with a hand pump, the nuts stripped off at a pressure of 125 lb. per sq. in. on the 8 in. blind flange. To bring this value down to the 100-lb. mark desired, the bottoms of the nuts were faced off slightly, the sheared metal melted out, and the center again recast and rethreaded.

Three sets of strip-out nuts then should yield points of 97, 103 and an even 100 lb. and a supply of nuts were faced to the proper thickness and made up for stock. It was calculated that the flange had to travel ½ in. to relieve any volume which might need to be released through error into the suction header. To limit the travel, a section of 6 by 6 in. timber was supported in the pit to stop the flange and prevent fracturing it against the pit wall.

Since adopting the "strip-out" nuts as standard, they have been painted red, and kept in a box under the chief engineer's desk, to prevent their being used in other locations. Steps are now under way to change over all relief flange bolts from standard right-hand to standard left-hand threads to prevent their use in other locations even by workmen who might deliberately disregard the distinctive color.

To insure uniform metal and correct melting conditions, the nuts are all filled with linotype metal from a local print shop—as the metal there is properly blended and its melting temperature accurately controlled by thermostatic regulation. In the case cited the casting of each nut cost the pumping company six cents—or 48 cents per flange—as against many times that amount for even one damaged fitting.

Longview, Tex. ELTON STERRETT.

Unburned Combustible—The Feud Continues

IN THE "READER'S CONFERENCE" of the July issue there appeared a communication from Mr. Adolph Johnson which pointed out the "fallacies" in my article on the effects of unburned combustible. I am reminded of an old professor of mine who continually reiterated, "An argument consists of two people talking about different things at the same time. When each begins to talk about the same thing, the argument disappears." Either Mr. Johnson has not grasped the point which I intended to make, or I have not made myself sufficiently clear.

It is axiomatic in all problems of combustion that "when you don't burn fuel, you don't get flue gas". It is quite true that coal which is fed to a stoker and

which spills over into the ashpit unburned contributes nothing to anything but the coal bill. This is exactly the idea which I intended to convey. Neglecting to give proper consideration to this unburned combustible will change neither the material products of combustion nor the real fan and design requirements, but serious mistakes in design can result from what might be called the *imaginary* gas weights arising from neglected carbon.

Mr. Johnson shows two heat balances; one in which the carbon losses are considered, the other in which the carbon losses are "neglected". He demonstrates thereby that the resulting gas weight in either case is substantially the same. But a comparison of these heat balances, which are here reproduced, discloses several interesting facts.

	Carbon Losses Considered	Carbon Losses Neglected
Dry Gas Loss	9.47	10.45
Hydrogen and Moisture Loss	3.31	3.31
Moisture in Air	2.36	2.59
Carbon Loss	10.00	0.00
Radiation and Unaccounted	4.00	4.00
Total Losses	29.14	20.35
Efficiency	70.86	79.65
Required Input, B.T.U./hr.	93,300,000	83,000,000
Weight of Gas Leaving Boiler, lb./hr.	91,100	90,000

Except for the losses due to the hydrogen and moisture in the fuel—which are in no way affected by the carbon content of the fuel—the two heat balances are in substantial agreement at only one point, the weight of gas leaving the boiler. Assuming that one of these heat balances is correct, the other must be wrong, and the single point of agreement must be regarded either as accidental or as the result of a series of compensating errors.

In the heat balance which "neglects" the carbon losses it will be seen that these losses are zero. This, as Mr. Johnson himself agrees, is ridiculous, since it supposes a stoker which is 100 per cent efficient. The overall efficiency in this case is 9 per cent greater than when the carbon losses are considered. Obviously such a gain in efficiency cannot result from merely refusing to admit that any carbon losses do exist. This false efficiency leads in turn to a required input which is less than the true required input. But the positive difference of the two inputs is just enough to balance the negative difference of the two weights of gas per pound of fuel. The total weight of gas leaving the boiler is thus very nearly the same in both cases.

This similarity of results is caused by a series of compensating errors. The effect of the unburned carbon has not been neglected. It has been disregarded in the computation of the weight of gas per pound of fuel, and then carefully compensated for by assuming no carbon loss in the heat balance. Although this method does give the correct weight of gas leaving the boiler, it presents a misleading picture of events all along the line.

However, this method of calculation does have its use. It is frequently used by designers in preliminary calculations of gas and air weights, because it is less cumbersome than the exact method, and because it is not necessary to make any estimates of the carbon losses involved. It is never used in the final calculations.

Mr. Johnson is right in his statement that the gas weights shown in the right hand column of Table II in the original article are incorrect. The sole purpose of the table was to demonstrate the effects of such incorrect computations. Every engineer knows that whenever combustion occurs there will be carbon losses in greater or lesser degree, depending upon the method of combustion and the type of fuel. He therefore never fails to include this loss in his heat balance. But what many engineers fail to remember is that the unburned carbon must be taken into consideration in computing the gas weights per pound of fuel *when the carbon loss is shown in the heat balance.*

Thus the usual practice is to take the above heat balance for carbon loss neglected, and make the carbon loss 10 per cent instead of 0.00 per cent as Mr. Johnson correctly does. The result will then be: Input to furnace

$$\frac{60{,}000 \times 1100}{0.6965} = 95{,}000{,}000 \text{ B.t.u./hr.}$$

Weight of gas leaving the boiler

$$\frac{95{,}000{,}000 \times 12.637}{11{,}745} = 102{,}000 \text{ lb./hr.}$$

This gas weight is in error by over 10 per cent, and it was exactly this type of error that the original article tried to warn against.

Long Island City, N. Y. G. CAMPBELL KOHLAR.

When Steam Escapes

MANY USERS of steam appear to have peculiar ideas regarding its behavior when steam is allowed to escape into the atmosphere. I have seen, and no doubt every reader has seen, sketches or drawings of escaping steam which are obviously incorrect. In these drawings the steam is made to appear as though it doesn't expand at all until it has moved out into the atmosphere a considerable distance, and there it is pictured as suddenly developing into a sort of round white cloud.

It has occurred to me many times that somebody should say something about this common error because the sketches are certainly incorrect. However, nobody has ever ventured forth to do any criticizing, so far as I know, so, after having just seen another such sketch, here goes:

When steam passes through any opening from a lower pressure into a higher pressure, it "immediately" begins to expand as soon as the lower pressure is reached. It is perfectly natural that it should. The volume of steam increases very rapidly, strictly in accordance with well known expansion laws. As a result the correct formation of the jet being emitted is more like that of a phonograph horn, the curve being "concave" outward because the expansion is at an increasing rate. It is NOT straight, as is so commonly

pictured in our magazines. In fact according to the sketches that we see the steam moves along just as though it were still in a pipe. It "doesn't know" that it is out in the wide-open spaces.

The same is true of air or any other gas under pressure being forced out through an opening from a higher to a lower pressure. These gases do NOT move along a straight line as so commonly pictured, for the same reasons as explained above.

To be sure, liquids are "different". Thus ordinary cold water exits without any expansion and in a line that is almost straight, much depending on the velocity of the water. But even with water exiting through a horizontal pipe opening, the profile line is not straight; it bends downward slightly due to gravity, and there is no expansion whatever and no enlargement.

If water is blown out through a blowoff valve, and if the water is hot, steam will be generated by the heat in the water as soon as the water exits through the opening and a curved volume again results, just as though the steam emitted contained no water whatever, in strict accordance with the expansion laws for the amount of steam that would be generated by the heat contained in the water.

The best way in which to show the true behavior of escaping steam, water, or anything else, is to take actual photographs of them and show the true-to-life pictures.

Newark, N. J. W. F. SCHAPHORST.

Fixing Rubber Bands to Conveyor Pulleys

RUBBER bands on conveyor wheels not only increase the grip between the belt and the pulley but also prevent wear on the pulley itself which, if the belt tension is high, may be considerable. The wear occurs on the rubber lagging which is renewable. To apply these bands, the face of the pulley is first cleaned with gasoline, the rubber band is then placed in position, and should be a fairly tight fit on the pulley. Then, with a screw-driver, lift up the rubber band and place under it a pencil or round piece of wood of like diameter and withdraw the screw-driver. The pencil can then be rotated round the pulley and in doing so will lift up the rubber band at all points in turn. At the back of the pencil there will be a small space, if a thin wooden stick is cut and dipped in a rubber cement for joining rubber to metal the whole of the metal can be cemented. The pencil should then be withdrawn and the natural pressure of the rubber on the metal will give a strong joint.

If a rubber band has to be removed it should first be cut through at one point. A hacksaw lubricated with water is good for this work. Then, by means of a blow lamp, heat the inner metal side of the pulley rim, a great amount of heat will not be necessary to weaken and crack the cement. Then the band can be peeled off by means of a screw-driver. Heat about 3 in. of the pulley at a time and work progressively around.

When the band has been removed the metal face can be cleaned with gasoline and a new band put in position if so desired.

London, Eng. W. E. WARNER

Preventing Furnace Explosions

FOR A GREAT many years research men, designers and operating engineers have been working on the problem of reducing the frequency and severity of boiler explosions. As the result of these efforts we have the modern boiler safe, even though subjected to extremely hard service requirements. Improvements in operating technique have kept pace with refinments in design and today explosions of the boiler proper are relatively infrequent. Modernization exacts its price, however, and with the introduction of more efficient fuel burning methods there has been a great increase in the number and violence of furnace explosions. While not so dangerous as those caused by rupturing of the boiler metal these explosions often do an enormous amount of damage and may be said to have superseded boiler explosions in number one place among the more destructive hazards of power plant operation.

Furnace explosions are caused by the instantaneous ignition of an accumulation of gaseous or finely divided combustible material mixed with or suspended in the air within the setting. Troubles of this nature are usually termed in the order of their magnitude as flarebacks, puffs, and explosions. Flarebacks and puffs ordinarily do little structural damage although they may dislodge baffles. Their greatest danger is to operating personnel who may be injured by flames or hot particles blown out of the furnace. On the other hand violent explosions may wreck the boiler setting and endanger the lives of persons in the vicinity.

In the great majority of instances these disturbances are experienced when firing the more explosive fuels such as gas, oil, and pulverized coal. Happily, with the widespread application of these fuels, both designers and operators have become more familiar with the hazards involved and are rapidly working out adequate safeguards. Among these are:

1. The installation of explosion doors or vents in the setting to relieve suddenly developed furnace pressures.

2. Interlocking of fuel-air supply and induced draft controls to avoid explosive mixtures when lighting off.

3. Auxiliary ignition devices or pilot lights to insure the prompt restoration of flame after an interruption in fuel supply. These are often supplemented by photo-cells arranged to shut off automatically the fuel until the operator can manually adjust controls for safe ignition.

4. Appreciation on the part of personnel of the dangers resulting from improper operation. Each installation presents the individual problems but a good operator will always observe the following precautions:

(a) Always vent the setting thoroughly by means of the damper or induced draft fan before lighting off or attempting to restore ignition after a temporary loss of flame.

(b) Keep lighting off devices in good condition and be sure they are properly placed and burning before introducing fuel.

(c) Never attempt to light a burner from another burner.

(d) If no pilot light is provided keep an oil torch or other means of ignition constantly burning when carrying very light loads.

(e) Use care when operating soot blowers to avoid disturbing furnace conditions, particularly where the boiler dust contains much unburned carbon.

(f) Make changes in fuel-air supply gradually to avoid complications.

(g) Guard against leakage of fuel into the setting when the boiler is banked or out of service.

(h) Observe furnace conditions closely when performing any operation which may cause an upset.

Stoker fired furnaces are ordinarily immune from explosion troubles. Difficulty is sometimes experienced, however, when the boiler is banked with the damper tightly closed. Under these conditions volatile gases may be distilled from the green coal in the fuel bed and explode with considerable violence if suddenly ignited. The best insurance against this eventuality is to crack the damper sufficiently to carry off the unburned combustible gases and to avoid leaving the fire in a shape that will contribute toward the formation of these gases.

Roanoke, Va. S. H. COLEMAN.

Danger of Oil in Boilers

OIL EVEN in small amounts in a steam boiler is dangerous. Any evidence of oil should be carefully noted and steps taken to prevent if possible its entry into the boiler. Oil in boilers generally comes about by the use of an open type heater where cylinder oil in the exhaust steam gets into the boiler feedwater—or if a condensing plant the condensed water will have its quota of oil from engines or pumps with cylinder lubrication. The oil may be partially eliminated by exhaust line eliminators or by filters in the hot well but when the oil makes a milky emulsion with the feedwater it is practically impossible to get it all out. The least objectionable oil is a high grade purely mineral oil of high fire test used for cylinder lubrication. Some cheap cylinder oils may be compounded with tallow or other animal oils which make an oil easily carbonized and highly objectionable in a boiler.

To demonstrate just how oil cuts down the efficiency of the heating surfaces of a boiler, take a cast-iron skillet with a heavy coating of burned grease on it, then clean or scrape one spot of it down to the bare iron and put the skillet on the stove with water in it. You will note that as the water heats up the steam bubbles will begin to rise from the bare spot long before they rise from the rest of the metal that has the burned carbon or grease on it.

Oil in a boiler will circulate till it reaches the hottest part of the boiler and then become attached and carbonize there. This is why the oil is often the cause of bags on the fire sheet of h.r.t. boilers and the cause of small bags on the lower side of the first pass of water tubes in a water-tube boiler. The peculiarity of this type of bag is that it does not come all the way down at one operation. The oil first burns fast, then collects some scale or mud in the gummy oil, then the spot overheats and gets almost red hot and starts to bag a little, then the coating on the inside breaks off and the spot cools down. Then in a few days or weeks the oil again settles in the same place and overheats, enlarging the bag or maybe puncturing through. In examining the first row of flues next to the fire on a fire-tube boiler, some of these incipient bags will be noted to have turned blue, thus bearing evidence that they have been overheated.

Also in some cases even before the bag is noticeable there will be a small spot on the lower side of a tube where fly ash or slag will stick to the tube and this is also a sign of overheating caused by some coating of oil or scale on the inside of the tube at this particular spot.

Oil is thus the cause of renewal of many tubes in water-tube boilers every year. To prevent this loss, it is well to inspect the inner parts of the boiler at every cleaning time and if oil is in evidence the tubes should be turbined. Also the use of a little caustic soda or soda ash in the feedwater is indicated to cut the oil.

Now and then a case occurs where some one gets oil in considerable quantity in a boiler, as for example the following case:

A certain factory was unloading oil (fuel oil) from a tank car. The car had a pipe coil in the bottom to heat the oil in cold weather so it could be handled with a pump. A steam line was run from an adjacent heating boiler in the basement to the tank coil. There was a leak in the tank coil and at night when the steam went down and a vacuum was formed in the boiler it sucked a lot of crude oil over into the boiler and the next morning when they built a fire in the boiler, as soon as the steam began to rise they had a violent case of foaming. The boiler had to be purged and boiled out with soda before they could use it.

A little oil in a boiler now and then also assists in promoting scale as the oil forms a sort of nucleus with sand, mud and lime to cement it together and stick it fast to the flues and heating surfaces. If not for the oil this sort of sediment could be dislodged by daily blowing down.

Logansport, Ind. C. C. CUSTER.

Licensed Operating Engineers

ACCORDING to R. S. Frederickson in the May issue of POWER PLANT ENGINEERING a man who possesses an engineer's license is, from the nature of things, competent to run a power plant. But so far as I could ever determine, a license is merely a scrap of paper and represents nothing but a certain amount of job protection to the holder.

I took two examinations here in St. Louis for a license and nothing was brought up in either of them to determine the qualifications of the applicant to operate a power plant. The questions were trivial in regards to the operation of a plant, and seemed to be designed more to quibble over, and so discourage the applicant, than to test his knowledge of the operating

principles of a plant. The questions were specific, to be sure, and needless to say I failed to pass, but I feel no chagrin in failing to pass, for I know of cases where chief engineers and master mechanics have failed and yet those men are responsible for some of the finest plants in St. Louis, and require a great amount of knowledge that the licensed man never possesses.

I have seen a licensed man work around half an hour trying to prime a centrifugal pump with a steam jet and after having given up, an electrician turned the steam jet on full and turned cold water off the jet and the pump primed in about half a minute. Yet according to law the engineer was fully qualified to operate any plant.

If a case like this occurred only occasionally one could not blame the license law for it, but these are everyday occurrences in the more modern plants. The statement is made among the licensed men that the questions in the examination are basic. Nothing is less true than that. The basis of all engineering is mathematics, physics, chemistry, mechanics and common sense. The examination doesn't try to find out if the applicant is familiar with any of them; it will ask a few specific questions about valve gear, a horizontal return tubular, a duplex pump, and other disconnected subjects, and if they are answered to the satisfaction of the "board" then a license is issued.

The modern up-to-date plant will have a variety of equipment such as air compressors, refrigeration equipment, vacuum pumps, high pressure boilers, air conditioning, high speed turbo-generators, and so on. On the operating staff will be, most probably, a chemist who is very likely to be a graduate from a university; an instrument man who is also likely to be a technical graduate; and of course electricians that can and will handle high voltage safely. They take the whole force and put them under a licensed man who may or may not understand what it is all about, and expect close harmony in the plant.

I believe a license law could be devised that would have a meaning in terms of safety and economy, but it will be necessary to place it in the hands of men who have the interests of the public and owners at heart.

St. Louis, Mo. E. DABLEMONT.

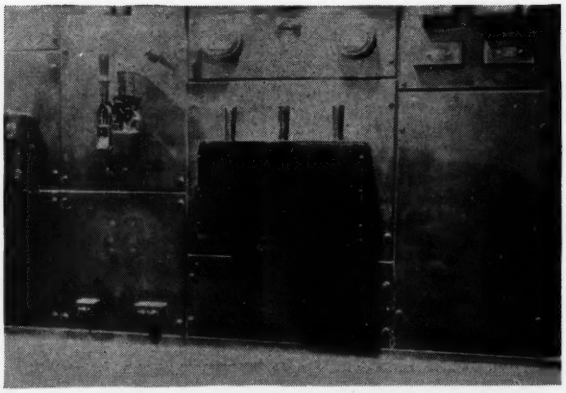
Eliminating Open Switch Hazard

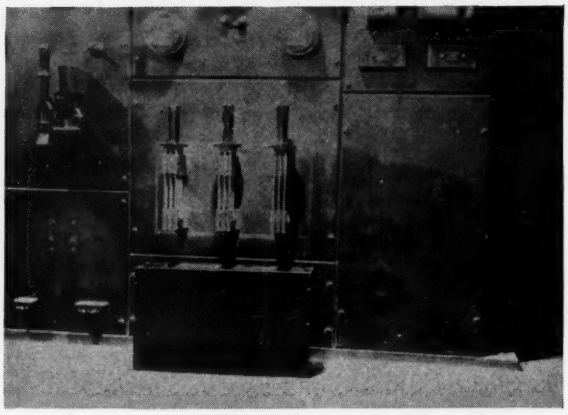
ON THE MAIN switchboard of a large industrial plant, the only exposed live parts were three 3000 amp. disconnecting switches set at a low level. These exposed switches were rightly considered a source of potential danger, and to protect the attendants a simple cover was devised as shown.

The material of the box-like cover is ½-in. ebony-asbestos-wood, held together by round-head wood-screws.

Three open-backed slots were cut into the top member, each wide enough to slide over the switch handles, and spaced to meet the handle-centers.

When in place the cover rests upon the three handle-guards, as shown, completely covering the live copper parts, yet requiring only a moment to remove should the need arise.





Switch cover to prevent accidental contact

Later, two 3-in. round holes were cut into both the top and bottom members so that air could circulate through the enclosed space, thus preventing any tendency to gather heat.

Providence, Rhode Island. JAMES P. MARSHALL.

WAY BACK WHEN in 1923 the Crown Willamette Paper Co. had a short center drive problem from engine to lineshaft, 550 hp. on 17 ft. 10 in. centers, after trying drive to countershaft and back to the lineshaft, a Link Belt Co.'s silent chain drive was installed consisting of two strands of 2-in. pitch chain, each 16 in. wide, driving from a 100-tooth wheel on the engine shaft to a 25-tooth pinion on the line shaft. Each strand used a little over 45 ft. of chain. Since installation, the drive has operated on the average 24 hr. a day for 350 days a year over the 14-yr. period, with practically no repairs, yet was found on recent inspection to be in good condition for many years more of service. The record made shows the possibilities of a well-planned drive of ample capacity, when given good care.

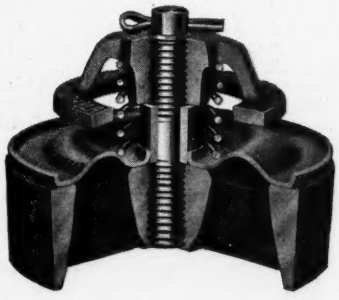
IN CERTAIN industrial plants, workers wear protective masks and gloves as guards against harmful fumes and dangerous liquids. Now telephones used in such plants are also being protected from corrosive damage, monel being used for the construction of exposed metal parts.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Durabla Pump Valve

IN THE LATEST development of Durabla pump valves, the open type guard allows an unrestricted flow of liquid, eliminates the possibility of spring clogging, and at the same time, protects the spring and limits the valve lift. The stud is kept from wear by a sleeve which also provides rigid support for the guard. The guard is readily removable, without lifting stud, for inspection of valve parts.



Durabla valves are die formed from non-corrosive alloy steel or monel sheets. They are rigidly designed with inner and outer upturned peripheral edges, making them light, strong, free moving, and durable.

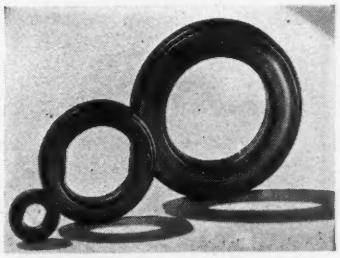
This valve service is available for use in any type of reciprocating pump, at all temperature-pressure combinations, and can be furnished completely fitted and ready to install.

Circuit Breaker

I-T-E HAS recently developed a combined, enclosed disconnect switch and circuit breaker for heavy mill service. A window in the front of the case permits the operator to actually see the opening of the disconnect contacts, thereby assuring safety at all times. The window is of shatter-proof glass, gasketed with heavy sponge rubber and bolted to the case. The standard blade type disconnect switch ahead of the circuit breaker is manually operated by a lever on the right hand side of the enclosure. The disconnect and the circuit breaker are interlocked so that the switch cannot be opened or closed while the circuit breaker is closed. The circuit breaker itself is an electrically operated, remote controlled device of the "K" type. The "K" type circuit breaker has been designed to give modified contractor service and at the same time high interrupting capacity and high speed in operation. The case is flanged and gasketed which makes it a reasonably dust tight enclosure suitable to dust-laden and corrosive atmospheres.

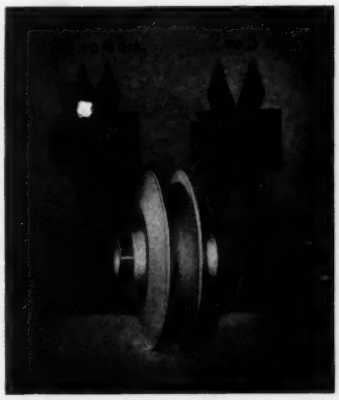
Valve Disc

THE GOETZE GASKET & PACKING CO., INC., New Brunswick, N. J., has perfected what is said to be a truly universal or all-purpose disc, recommended for handling air, gas, steam and liquids at any temperatures or pressures, for acids, alkalis or solvents, in fact for any service in which a globe valve can be used. This valve disc is of laminated construction, built up of alternating layers of asbestos and metal completely encased in a two-piece shell of copper, Monel or other alloy metal. The shell effectively protects the laminated parts of the disc. It affords perfectly flat seating surfaces, both top and bottom, and allows the upper ring freedom of movement under compression. Discs are made in sizes for ¼ to 12 in. valves, with round or oblong holes. They stand up well in all services and eliminate entirely the need for frequent replacements.



Adjustable Sheave

THE TEXROPE DIVISION, Allis-Chalmers Mfg. Co., Milwaukee, Wis., has developed an adjustable Texsteel Sheave, with a range of pitch diameter varying from 2 to 3 in., and from 3 to 4 in. by merely removing an adjustable plate, reversing and again placing on the hub. As shown in the picture, the outer plate in the position shown at left allows the Texrope Belts to ride high and give a pitch diameter anywhere from 3 to 4 in.; the outer plate reversed in the position shown at the right allows the Texrope Belts to ride low and give a pitch diameter anywhere from 2 to 3 in.; the two together providing for a speed variation of 100 per cent. This change takes but a moment. This sheave has been developed in response to a demand for a sheave that is low in cost and yet has a wide range of speed variation. It is especially well suited to the heating and ventilating industry.



New Gage Glass

A NEW gage glass featuring greater visibility, greater ease of illumination and greater safety has just been announced by Corning Glass Wks., Corning, N. Y.

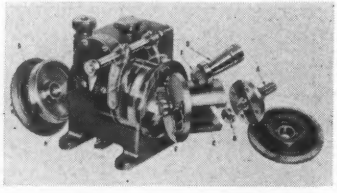
Known as the Pyrex broad red line gage glass, this glass differs from previous types in that the red stripe is transparent, is proportioned to the diameter of the tube, and is fused permanently to the wall of the gage glass. The transparent red line makes it possible for the first time, it is said, for the light to pass through the red stripe and the water column from the rear. Placed directly back of the new gage glass, a small slotted illuminator produces brilliant visibility under all conditions without any distracting glare. Proportioning the width of the stripe to the tube diameter makes the entire tube appear red below the water line instead of the usual slightly magnified stripe.

The new glass is made in lengths to 24 in. and diameters ½ in.-1 in., inclusive. It is machine drawn and of the same chemically resistant glass composition as used for previous Pyrex glasses. It thus retains the accuracy of size, thermal shock resistance, clarity and lack of "clouding" in service which have characterized these previous products.

Variable Speed Transmission

NEW MODELS of the Graham variable speed transmission with important additional features which broaden the scope and application of this type of equipment, have been announced by Graham Transmissions, Inc., 2711 North 13th Street, Milwaukee, Wis.

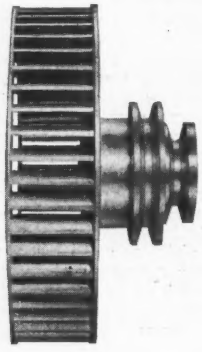
By means of a tractional device, which automatically keeps the drive pressure in proportion to both the load and the speed, the Graham maintains full torque all the way to zero speeds. It transmits full motor power over a range of 4:1, and gives speeds in infinite steps from any desired maximum all the way to zero and reverse. Speed is adjustable, either stationary or running.



It is believed that this significant development of a constant power drive will extend the use of variable speed transmissions into many new fields. In addition, the efficiency of the unit is considerably increased when applied to the already extensive field of constant torque uses, including conveyors, printing machines, textile drives, stokers, baking ovens, and many others. For machines requiring automatic control with extremely close speed regulation, this transmission is especially advantageous.

Cast Aluminum Fan Wheel

ADVANCE ALUMINUM CASTINGS CORP., 2742 West 36th Place, Chicago, Ill., is making a new type blower fan with the hub cast to form the driving unit of a flexible coupling. This fan marketed under the trade name "Castalu" is designed for service on oil burners, stok-



ers, air conditioning equipment and many other devices.

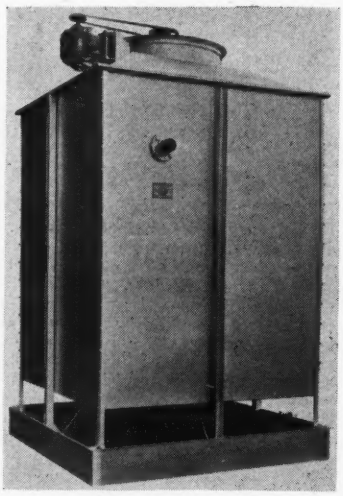
The Castalu fan is cast in one piece of non-corrosive and light weight aluminum. As no rivets are used long life and trouble free service is assured. The fan is accurately balanced, bored and reamed for shaft, drilled, tapped and fitted with set screw.

Important features claimed for this blower are that by having the flexible coupling driven unit as an integral part of the fan, motors having standard shafts can be used, and approximately one-third of the cost of the flexible coupling is saved. When, due to design of equipment, additional distance between motor and fan is required, instead of using a non-standard motor shaft or extra length hubs, a low cost, oil-proof synthetic rubber flexible coupling center unit of the right length is installed. These fans operate either clockwise or counter-clockwise, and are available in all standard sizes from 3 by 1½ in. to 10½ by 5¼ in. and bored to suit any shaft. They can also be obtained in special sizes, rotation, volume and hubs as specified.

Steel-Cased Cooling Towers

THE MARLEY CO., 3001 Fairfax Road, Kansas City, Kan., announces the addition to its line of water cooling equipment a complete series of small steel-cased induced draft cooling towers. These include horizontal wood filled types for use indoors and vertical types for outdoor service, either wood or spray filled. All models, indoor and outdoor, are entirely self-contained, with no protrusions or obstructions to present a cleaning problem. Patented Marley non-clog spray nozzles of bronze and galvanized steel pipe headers and nozzle arms are utilized in all of them.

The indoor towers are horizontal in construction and in air movement. Four standard sizes range from 2½ ft. by 7 ft. by 3 ft. 2½ in. to 2½ ft. by 8½ ft. by 6 ft. 8½ in. Casings and basins are



16 gage copper bearing steel, shop painted two coats. They are equipped with Marley fans with guard grills which may be removed when a discharge duct is used. Zig-zag drift eliminators of heart redwood and cast-iron spacers are built as one unit, easily lifted out for access to tower interior. Removable redwood decks and spacers constitute the filler through which the water filters down after down-spray injection at the top. These towers are shipped fully assembled, with simple instruction, ready for operation.

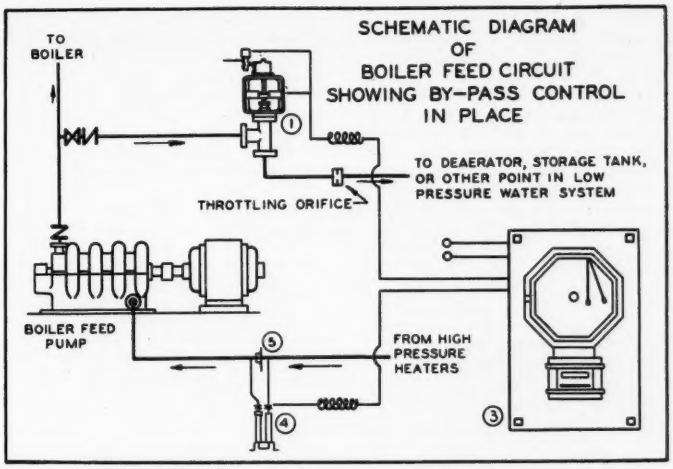
The vertical outdoor (illustrated) towers are available in either wood-fill or spray-fill types, each in 12 standard sizes from 2½ ft. by 2½ ft. by 9 ft. 1 in. to 10 ft. by 10 ft. by 14 ft. 3 in. They are equipped with multiple-effect drift eliminators of heart redwood with cast-iron spacers and Marley fans having "V" belt drives from motors mounted on the tower roofs. In the wood-fill type, water is upsprayed at the top and decking is of heart redwood. Two levels of downspray nozzles are provided in the spray-fill types. Both types are shipped knocked down in shop fabricated, easily handled units, which need only to be bolted together for immediate operation.

Universal Hand Tachometer

THIS new instrument, manufactured by James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa., measures any speed from 30 r.p.m. up to 40,000 r.p.m. with only three tachometer ranges. It is equivalent in speed coverage to former six-range hand tachometers. This is done by allowing the indicating pointer to make two turns around the dial in-

stead of one, thereby making the scale 13 in. long. One advantage is that a wide variation in speed can be observed, such as from 300 to 4000 r.p.m. without stopping to change the range.

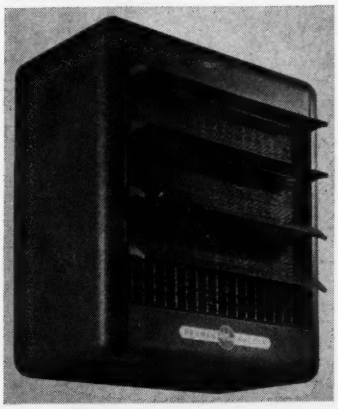
The "Jagabi" Universal Hand Tachometer operates on the same centrifugal or fly-ball governor principle as James G. Biddle Co.'s Type C Tachometers, but has been redesigned to include ball-bearings, a knife-edge pointer, a rotating gear shift and other refinements. The indicating dial is 3 in. in diameter. The shape, size and weight are such that it fits snugly and firmly in the hand, so that the operator is insured a firm and steady grip, which is so essential in using any tachometer. The instrument is supplied complete with carrying case and accessories. Two ratings are available: 30 to 40,000 r.p.m. and 25 to 30,000 r.p.m.



Propeller-Fan Type Unit Heater

FOR STEAM or hot water heating of all types of industrial and commercial buildings, the new Herman Nelson propeller-fan type Hijet heater is now available.

This fan is of new streamlined design with large face area, it combines quiet, smooth operation with high efficiency. The heating element is designed with loops to absorb difference in expansion and contraction between individual tubes. The entire tube and loop is fabricated of red brass with no connecting joint to weaken construction. Tubes project from the side of the supply header, above the center line, assuring proper distribution of steam. A stay tube maintains proper relationship between headers. The motor, for single, two or three speed operation, and fan assembly are mounted on steel arms designed to absorb and dissipate torsional vibration, preventing transmission of vibration to the cabinet. The louvers are adjustable and curved to direct heat downward. Grille or discharge nozzle may be used in place of louvers. The hanger and steam connection are located near the center of gravity for ease of installation.



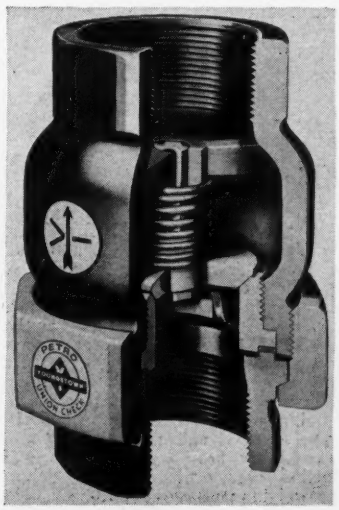
Eighteen sizes are available for use with steam or hot water. Air capacities ranging from 275 to 5060 c.f.m.

The Herman Nelson Corp., 33rd St., Moline, Ill., is the manufacturer.

Union Check Valve

A SPRING-CONTROLLED forged steel union check valve for the petroleum industry is announced by The Youngstown Sheet & Tube Co., Youngstown, O. Designed to handle full pipe capacity, the valve is built for up to 600 lb. steam working pressure or 2000 lb. cold working pressure and can be used in any position, vertical, horizontal or upside down.

The spring controls the opening and closing of the valve in accordance with the velocity of the flow, yet is so designed that it is not affected by sudden fluctuations of flow or back pressure. The valve has a hylastic vanadium cast steel body with tensile strength of 103,000 lb. per sq. in. and poppet and seat of high temperature and corrosion resisting bronze known as U. S. Navy Bronze 88-10&2. Made of phosphor bronze the spring will retain its tension on temperatures up to 650 deg. F. Poppet, seat and spring are heavily chrome plated to resist the corrosive action of crude oil and acids. Examination and replacement of poppet, seat and spring can be made without removing the valve from the line. The union check is made in three sizes for 2, 2½ and 3 in. pipe and is furnished with either standard or handle bar nut.



Pump By-Pass Control

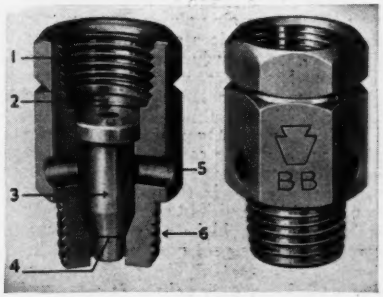
THE SMOOT AUTOMATIC pump by-pass control has been developed by the Republic Flow Meters Co., 2140 Diversey Parkway, Chicago, Ill., to prevent the over-heating of large high-pressure centrifugal pumps when operating under low load conditions—a major problem in the operation of centrifugal pumps handling fluids at high pressure and high temperature. Overheating is prevented by insuring at all times, a flow through the pump sufficient to carry away the excess heat generated in the pump. This is accomplished automatically by a simple controlled system consisting essentially of a Republic flow meter body (4) and flow nozzle (5) in the pump suction line controlling a valve (1) in the pump by-pass line.

When the flow through the pump reaches a measured predetermined low flow (an amount below which there is a danger of the pump overheating) the pump by-pass control automatically opens a by-pass valve permitting a measured amount of water to flow from the pump discharge to some convenient point in the feedwater circuit from which it will flow back to the feed pump suction.

The pump by-pass remains open until the flow through the pump increases to a second predetermined rate of flow at which point the by-pass valve is closed automatically. This overlap between the opening and closing point of the control, prevents the control from hunting by eliminating a critical "on" and "off" control point. A two pen recorder (3) records on a single chart the total flow of water through the pump, the amount of water by-passed, the time the by-pass opens, the duration of opening and the time the by-pass closes. Thus a complete record of the operations of the pump and by-pass are always available. A light or horn signal can be employed with the by-pass control for the guidance of the operating staff.

Lubricating Fitting

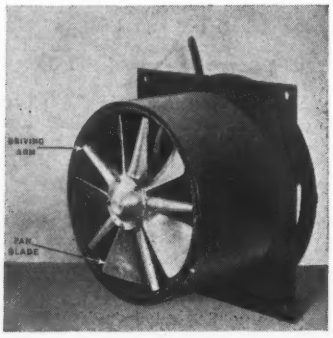
DEVELOPED by the Keystone Lubricating Co., Philadelphia, Pa., the new Keystone BB fitting is used in connection with the present grease cup on high pressure fitting at the bearing. This fitting insures proper lubrication and under no circumstance is it possible to over lubricate a bearing under high pressure.



They are made in ⅛ and ¼ pipe thread sizes. Lubricant passes from pressure fitting or grease cup through inlet (2) into hollow calibration tube (3), thence into bearing. When the bearing has received the proper amount of lubricant, any excess passes back through calibrated space (4) to escape ports (5), where it is immediately visible.

Fanmix Gas Burner

GAS BURNERS employing an entirely new principle of mixing air and gas have recently been introduced by Coppus Engineering Corp. of Worcester, Mass. Whereas heretofore all gas burners could be classified in three groups, the venturi type, the ring type and the center fired diffusion type, the Coppus-Dennis Fanmix gas burner is of rotary type, consisting primarily of a fan with a long hub in which two ball bearings are



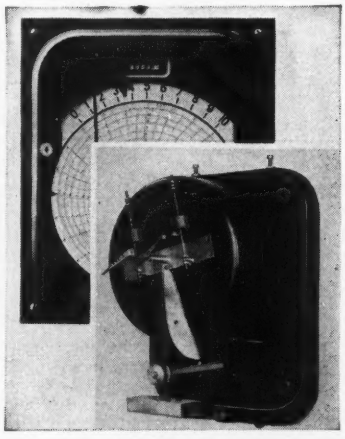
mounted, so that the fan rotates on a stationary shaft which serves at the same time as gas inlet pipe. The gas is admitted through the hollow shaft and enters the fan hub. The fan has several air blades as well as driving arms. The gas flows into these arms, leaves them through small orifices and, by reaction, causes the fan to rotate at high speed. The fan blades then act as any other power driven fan, delivering air for combustion. As the air flows in a direction parallel to the shaft and the gas flow is in a plane practically at right angles to the air flow, very thorough mixture of gas and air is obtainable directly at the fan.

The number of orifices in the driving arms as well as the gas pressure determines the total amount of gas flow and its reaction force determines the speed of the fan and hence the air delivery. The fan can therefore be designed so that there will be a definite ratio between gas and air. If a lower rating is desired, the gas pressure is reduced, decreasing the total amount of gas flow and also causing the fan to slow down, thereby reducing the air volume. Thus, at the lower ratings, again a practically perfect ratio between air volume and gas volume is obtained; any final adjustments of the air volume can be made with the inlet shutter.

With a perfect combustible mixture discharged into the combustion chamber, instant ignition is possible and small combustion space is required. In operation, no flame is visible. This gas burner is primarily a high pressure burner, operating at gas pressures of 5 to 40 lb.

Gas Flow Meter

THE COCHRANE ring-balance flow meter for low pressure gas measurement, made by Cochrane Corporation, Philadelphia, is designed for operating differentials as low as 2 in. of water and is particularly applicable to measurement of gases at pressures below those for which the customary types of mercury-sealed flow meters are suitable. The meter consists of a ring-shaped hollow body, rotably supported on knife edges at its center, so as to be capable of turning freely. The annular body is partly filled with water, oil or air anti-freeze liquid, and is divided at the top by a partition wall, to each side of which a flexible tube is led for the purpose of subjecting the unit to the differential pressure from an orifice or flow nozzle through which flow is to be measured. When flow occurs through the orifice plate, the re-

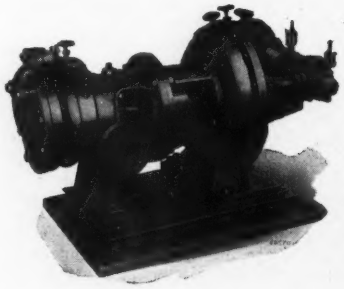


sultant differential pressure causes the liquid in the ring balance to be transferred from one side to the other, whereupon the ring balance rotates to a new position of equilibrium. Motion is maintained proportional to flow by a suspended weight and cam.

Turbine Pump Unit

INGERSOLL-RAND CO., 11 Broadway, New York, N. Y., announces a unique new turbine-driven pump featuring a compact construction that combines both turbine and pump as one unit on a common shaft. This pump, shown as the "class TRV" is built in single-stage sizes for capacities from 5 to 1000 gal. per min. against heads as high as 220 ft. and in two stage sizes for capacities to 275 gal. per min. and heads up to 550 ft.

The featured unit assembly of pump and turbine makes possible a substantial reduction over ordinary turbine-driven pump weights and sizes. A 15-hp. single



stage unit is about 32 in. long and other sizes are proportionately small. No special foundation is required and units are available for operation in any position. They may be bolted to the floor, wall, tank, column or ceiling, as is most convenient.

Suitable for use wherever a turbine-driven pump is desirable and replacing many older duplex steam pumps, these units are particularly applicable for use in refineries, chemical plants, mines and other locations where hazardous gases are present. They are equally adaptable for general industrial service where process steam may be utilized, as well as for boiler feed service at boiler pressures up to 200 lb. per sq. in. When steam is not available, the turbines can be efficiently operated on compressed air.

Portable Pyrometer

ILLINOIS TESTING LABORATORIES, INC., 420 N. La Salle St., Chicago, Ill., announce the introduction of a new shockproof portable pyrometer. This instrument has a spring suspended movement within the case to minimize shocks and jars and the movement is mounted on pivots and jewels especially designed

for unusually severe service. It has a scale length of 5 in. protected by shatter-proof glass, is mounted in a heavy metal case to prevent breakage if accidentally dropped. It also has a new type pointer lock to damp the movement of the instrument while it is being transported. The case is $7\frac{7}{16}$ in. wide, $6\frac{3}{16}$ in. high and $2\frac{13}{16}$ in. deep.

Vari-Speed Motodrive

NEW FLUID pressure type of automatic or remote control of the Vari-Speed Motodrive is announced. Air, gas, vapor or liquid may be used as pressure-transmitting medium, air giving the most rapid action to change speed over a range of 6:1 in 2 to 4 sec. Speed ratios are available from 2:1 to 6:1 in capacities from ¼ to 10 hp. The shifting is by a bellows mechanism mounted on the unit with piping and valves as needed. Fluid pressure used ranges from 5 to 30 lb. per sq. in. according to the size of unit and speed of action required. Reeves Pulley Co., Columbus, Ind.

News from the Field

On June 22, Arthur W. Chesterton died at the age of 80 years. He was the founder of the A. W. Chesterton Co. of Boston, Mass., manufacturers of mechanical packings and steam specialties. Born in England in 1858, he was one of the pioneers in the mechanical packing field, being the first to introduce a compressed asbestos sheet packing in the United States. The first high pressure gage glasses were introduced by him, as was the red reflecting strip to make the water line visible in gage glasses.

E. Gordon Campbell, Mechanical Operating Engineer, in the Power Stations Department of the Duquesne Light Co. died on June 23, 1938. Mr. Campbell was born in Charleston, South Carolina, and was graduated from Clemson College. He then was employed by the General Electric Co. at Schenectady for 3 yrs.; thereafter for 2 yrs. in Panama at the Isthmian Canal Commission in charge of electrical construction and operation. After returning from Panama, he was in charge of engineering and construction on many large power projects, until 1926 when he entered the employ of the Duquesne Light Co. Mr. Campbell was a member of the New York State Society of Professional Engineers and the American Society of Mechanical Engineers.

Joseph H. Hayden, secretary of the Hewitt Rubber Corp., Buffalo, has been elected a member of the board of directors of the company, it was recently announced by Thomas Robins, Jr., president, following a meeting of directors. William S. Carleton of New York City, and Lester D. Bigelow of Chicago, have been elected vice presidents of the company, it was further announced.

After 22 years as superintendent of the Poplar Bluff (Ark.) municipal light and water plants, A. E. Hecker has resigned. Differences between the city council and the Board of Public Works brought repeal by the council of a 1916 ordinance creating the board. The action was followed by Hecker's resignation.

George C. Meyer, president of the Cord Meyer Development Co. at Forest Hills, L. I., on July 8 was named a director of the New York & Queens Electric & Power Co. He succeeds Philip Torchio, vice president of Consolidated Edison Co. of New York, who after nearly 40 yr. with the Edison system, will retire in August when he reaches the company's retirement age of 70. Meyer has been a trustee of Consolidated Edison Co. since 1935.

C. J. Strike, of Huron, S. D., resigned as president of the Northwestern Public Service Co. to accept the presidency of the Idaho Power Co., succeeding Kinsey M. Robinson, who resigned on June 4 to become president of the Washington Water Power Co. Mr. Strike, who has been in the utility field for 23 yr., started as a lineman in 1915. He organized and became president of the Consumers Electric Service Co., at Webster, S. D., in 1921, and became sales manager of the Northwestern Public Service Co. in 1924 when that company absorbed the Consumers company. In 1931 he was made vice president and general manager, and in 1937 became president of Northwestern Public Service. Well known in the utility field in the middle-west, he is a past president of the North Central Electric Association.

Frank A. Coffin, sales manager for the Milwaukee Electric Railway & Light Co., has been named a vice president of the company.

H. W. Scott, of Columbia, S. C., has been named chairman of the South Carolina Public Service Commission, succeeding Josiah J. Evans, Bennettsville.

E. S. Cary, Evansville, has been named president of the Wisconsin Municiptal Utilities Association, succeeding W. C. Staeffler, Manitowoc.

Harry B. Matzen, formerly Vice-President of the Carrier Engineering Corp., has organized a consulting engineering service for air conditioning and refrigeration with offices at 185 Madison Ave., New York. Mr. Matzen has been associated with air conditioning engineering work both with Carrier and the York Ice Machinery Corporation for the past 22 yrs. From 1925 to 1935, he was manager of Carrier's Cleveland office.

J. L. Singleton, who has been in charge of Allis-Chalmers Mfg. Co.'s Denver District Office, has now been appointed Manager of that office.

At the July meeting of the Board of Directors of The Buda Co., Harvey, Ill., L. M. Viles, President for over 20 yrs., was elected to the position of Chairman of the Board. J. S. Dempsey, who has served the company for many years as Secretary-Treasurer, and Vice-President, was elected President to succeed Mr. Viles. At the same time, F. E. Place, who has been associated with The Buda Co. since 1908, retired as Senior Vice-President. An executive committee consisting of Mr. Dempsey and two Operating Vice-Presidents, R. K. Mangan and E. D. Conant, will direct the affairs of the company.

Roy Kendall, formerly assistant chief engineer of the Piqua, Ohio, municipal plant, has recently been appointed chief engineer of Brand Whitlock Homes, Toledo, a Federal Housing Administration project.

Curtis S. Mitchell, Vice President and Controller of the Philadelphia Co., Pittsburgh, Pa., died July 23, in Washington, D. C.

Mr. Mitchell was born in Beaver Pa., and on August 16, 1897, he entered the service of the United Traction Co. of Pittsburgh, and on April 1, 1898, was made auditor of the company. When the Philadelphia Company acquired control of the Allegheny County Light Co., the Consolidated Gas Co. of Pittsburgh, and United Traction Co. of Pittsburgh, Mr. Mitchell was appointed Assistant Auditor. In 1912, he was elected Controller of these companies, and a vice president of the Philadelphia Co.

Continental-Diamond Fibre Co., Newark, Del., recently installed a 615 lb., 625 deg. F. power plant with one Vogt Type VV, 45,000 lb. per hr. boiler, and, a 5000 kw. G.E. turbine exhausting at 115 lb. to the process system. The boiler can be fired by a Strong-Scott pulverizer or by fuel oil and the feedwater system, designed by W. H. and L. D. Betz, is a combination of zeolite with acid feed and supplementary interval treatment. A Swartwout reducing and desuperheating station is in parallel with the boiler to maintain steam pressure on the process line. The plant was designed and installed by the company's engineering department; C. S. Rankin, chief engineer, and R. R. Vennum, assistant.

N. I. A. A. at Cleveland

During September 21, 22 and 23 Cleveland, O., will be host to the National Industrial Advertisers' Association when it meets for its annual conference at the Statler Hotel. This association, whose members are composed principally of those men in industry who dictate the advertising policies of their companies and direct their publicity campaigns, has planned a program which will deal with general as well as specific publicity problems.

Among the general topics are: A Census of Industrial Markets; Industrial Trends Which Challenge Industrial Advertisers; Public Relations and Employee Relations; Trade Shows and Exhibits. Coming to the more specific problems, discussions will take place on: Direct Mail for Industrial Advertiser; A Better Creative Job—Ideas, Copy, Art, Photography; Publications and Their Evaluation; Catalogs and Sales Manuals; Departmental Organization and Budgets; Preparing the Plan; Finding the Facts; Creating the Copy.

This conference might well be called the advertising style setter for the year, as out of it will come ideas and technique as well as company policies that will prevail in all advertising in the industrial field. To aid in visualizing modern trends in advertising, fifty some exhibit booths will be occupied by publications to display and demonstrate their services to the field. E. B. Bossart, Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, O., is chairman of the Attendance Promotion Committee and is in position to furnish detailed information on the conference.

Ames Extends Power Plant

Additional steam generating capacity is being installed at the municipal light plant, city of Ames, Iowa, and according to C. H. Ames, City Manager, is expected to be on the line about September 1. This addition consists of two 400 lb., 750 deg. F., 40,000 lb. per hr. Foster Wheeler bent tube boilers, fired by 140 sq. ft. Illinois forced draft chain grate stokers. The 1400 cu. ft. furnaces have a total of 267 sq. ft. of side and rear water walls, made up of 3¼ in. bare tubes spaced on 6 in. centers and rectangular water boxes on both sides of the stoker.

Stokers are driven by 3 hp., 1200 r.p.m. motors and each furnace is equipped with a Buffalo Type V overfire air fan direct connected to a 5 hp., 3460 r.p.m. motor. Each boiler has a 2160 sq. ft. Foster Wheeler extended surface economizer, a Green double inlet induced draft fan and a Buffalo Forge double inlet forced draft fan.

Feedwater will be heated in an Elliott 60,000 lb. per hr. deaerating heater and a Schutte & Koerting 206 sq. ft. closed heater. The boiler feed pumps are De Lavel 7 stage, rated at 90 g.p.m. against

head of 1380 ft. One is driven by a 60 hp., 3500 r.p.m. motor and the other by a 55 hp. turbine operating at 175 lb. gage, 100 deg. superheat. Cumbustion control was supplied by Republic Flow Meters Co., recorders and miscellaneous meters by the Bailey Meter Co., the steam header by Crane Co. and soot blowers by Vulcan Soot Cleaner Co.

Henry Laidlaw

HENRY LAIDLAW of Detroit, Mich., widely known in the pumping machinery world, died in Kingsville, Ontario, Canada, on June 25 of a heart ailment and was later buried in Cincinnati, O. He was born in Innerleithen, Scotland, June 6, 1860, and came to the United States in 1880. In 1887 he joined his brother Walter Laidlaw, one of the founders of the Laidlaw-Dunn-Gordon Air Compressor Co., and became the first salesman for this new company. When the International Steam Pump Company was formed in 1898, with the Laidlaw-Dunn-Gordon Co. as a member, he became sales manager of the company's Detroit District Office, and remained with its successor. The Worthington Pump & Machinery Corp., until 1927 when he was made special representative for the same office.

Coal Engineers to Convene in Chicago

ON OCTOBER 13 to 15, coal engineers and operators from all over the country will gather at the Palmer House, Chicago, for a meeting, centering on recent developments in producing and preparing coal for industrial and home use. This meeting is jointly sponsored by the American Society of Mechanical Engineers (Fuels Division), the American Institute of Mining & Metallurgical Engineers (Coal Division) and the Western Society of Engineers. Cooperating with these societies will be the Illinois and the Indiana Mining Institutes.

As lined up, the program assigns the first two days to general technical sessions, all papers of which will be of interest to the entire gathering. On Friday afternoon, however, several alternate sessions of special interest to certain of the groups will run concurrently with the general session, while for Saturday, several separate inspection trips have been planned.

The papers outlined for the general sessions will touch on such subjects as the following: stokers; coals for steam generation and domestic use; coal hydrogeneration; strip mine equipment; screening and materials handling in coal preparation plants; effects of the properties of coal ash; underground mechanization and ventilation. A high point of these sessions is expected in the projected panel discussion by four authorities, each handling a different phase, regarding coal purchasing. A number of excellent papers are announced for the special concurrent sessions on Friday afternoon.

On Friday evening, the regular dinner event will be held, with Dr. W. L. Abbott as toastmaster, and as principal speaker, Howard N. Eavenson, well known consultant from Pittsburgh, and a past president of the A.I.M.E.

A. C. Carlton, Museum of Science and Industry, is General Chairman of the combined committees from the three societies, in charge of arrangements; and Ralph E. Turner, Editor of POWER PLANT ENGINEERING, is Vice-Chairman. Others on the committee include: C. C. Austin, Mancha Storage Battery Co., H. M. Black, Sargent & Lundy, L. M. Ellison, Ellison Draft Gage Co., H. F. Hebley, Commercial Testing & Engineering, F. B. Orr, Illinois Maintenance Co., Daniel Roesch, Armour Institute of Technology, T. B. Counselman, The Dorr Co., A. I. Edwards, Raymond Pulverizer Division, C. F. Hamilton, Binkley Coal Co., Carl T. Hayden, Sahara Coal Co., Dr. M. M. Leighton, Illinois State Geological Survey, Paul Weir, Consulting Engineer, and J. S. Y. Fralich, Westinghouse Air Brake Co.

Philip Torchio

PHILIP TORCHIO, vice-president of Consolidated Edison Co. of New York, Inc., retired August 2, in accordance with the company's seventy-year age limit. Born August 2, 1868, in Vercana, Como, Italy, he began his career with the Edison companies in January, 1895, when he was employed as a draftsman by the Edison Electric Illuminating Co. of New York, predecessor of The New York Edison Co. Four years later he was made

Philip Torchio

statistician, then engineer of economics, engineer of distribution, chief electrical engineer and in 1924 vice-president in charge of electrical engineering. At this time, he also acted as consulting engineer of the United Electric Light and Power Co., the New York and Queens Electric Light and Power Co., the Yonkers Electric Light and Power Co., Westchester Lighting Co., and the Bronx Gas and Electric Co. Mr. Torchio is best known in the industry for the work he has done in the development of electricity in steam and hydraulic stations and in the unification of systems of transmission and distribution over large territories.

George L. Davis

THE DIAMOND POWER SPECIALTY CORP. announces the appointment of George L. Davis as Vice-President in Charge of Sales. Mr. Davis joined the Diamond organization in February, 1924. After 2½ yr. in the Chicago Sales Office, he returned to the main office in Detroit as Assistant Sales Manager in September, 1926. Prior to joining the Diamond Power Specialty Corporation, Mr. Davis worked for 4 yr. in both operating and sales departments of the Oliver Iron and Steel Corp., Pittsburgh, and for 2 yr. in the sales department of the Calorizing Co., Pittsburgh. Mr. Davis

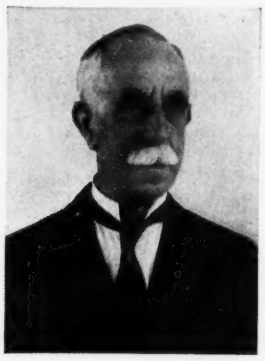
George L. Davis

was educated at Kiski Preparatory School and at Lafayette College in mechanical engineering. During the war he served as a second lieutenant pilot in the U. S. A. Air Service.

James Tribe

JAMES TRIBE, one of the engineering staff of Allis-Chalmers Mfg. Company since 1899, died August 13th, at the age of 82.

Born in Oxford, England, on January 15, 1856, Mr. Tribe came to America and started to work for the George H. Corliss Company of Providence, R. I., in 1881. In 1890 he opened a consulting en-



James Tribe

gineers office at Providence. In 1893 he established a connection with the Hoffman-Billings Company of Milwaukee when they began to design and develop Corliss steam engines. About the same time he became associatd with William Horlick, Sr., of the Horlick Malted Milk Company of Racine, Wis. As superintendent here he invented several machines which were of great value to that company. He remained in their employ until his association with Allis-Chalmers.

As early as 1889 Mr. Tribe joined the American Society of Mechanical Engineers and in 1925 was honored with a life membership.

Santee-Cooper Development

To AID in the construction of the $37,500,000 Santee-Cooper power and navigation project in South Carolina, the P. W. A. has alloted $10,500,000 and has approved the contract of the South Carolina Public Service Authority with the Harza Engineering Co. of Chicago for engineering services. Kenneth W. Markwell has been appointed as P. W. A. Project Engineer.

This project, held up by litigation until the Supreme Court decision last May, will be one of the largest and most spectacular developments in the South. It consists of two dams, one 6 mi. long on the Santee River and the other 2 mi. long on the Cooper River, with 26 mi. of dykes flanking the main dam; transmission lines; navigation locks on the Cooper River; combined navigation and diversion channel between the two rivers and paralleling the old Santee Canal.

It will provide direct navigation facilities connecting Charleston and Columbia and shorten the present route by many miles. Hydroelectric power to be generated at the Cooper dam is estimated as 450,000,000 kw-hr. of firm and 25,000,000 kw-hr. of secondary power, giving a total of 700,000,000 kw-hr. annually.

Rubber and Plastics Committee

BECAUSE of rapid increase in the applications of rubber and plastics, a committee has been established by American Society of Mechanical Engineers to cover research on properties, processing equipment, standards and mechanical applications of these substances. The committee will sponsor presentation of papers at technical sessions of the Society, papers on History of Rubber, on Rubber-like Synthetic Parts, and on Some Mechanical Properties of Rubber being included in the program for the quarterly meeting at Providence, R. I., Oct. 5 to 7.

Authors offering papers for presentation at future quarterly meetings should communicate, at least 4 mo. in advance of the date of a meeting, with Dr. J. F. Smith, Edward G. Budd Mfg. Co., 25th St. and Hunting Park Ave., Philadelphia, secretary of the committee, or with Dr. F. L. Yerzley, E. I. du Pont de Nemours & Co., P. O. Box 525, Wilmington, Del.

Bonneville Again

WHILE J. D. Ross, Bonneville Administrator, was lifting the cover on his crystal ball to let the Seattle Engineers Club (see page 583) peek ahead to the day when New York is supplied with 1,500,000 kw. of Columbia River Power, he was also busy with the more immediate problem of disposing of the present Bonneville power supply.

To test out the feasibility of interconnected operation during a period of normally low output from hydroelectric plants of the Northwestern Electric Co., the Administrator entered into a contract with the company, dated July 26, 1938, and extending to Oct. 31, 1938. The contract provided for 2500 kw. of firm power and 2500 kw. of secondary power, with a maximum demand of 10,000 kw. to be delivered at 66 kv. at N. Bonneville, Wash. The rate schedule, approved by the Federal Power Commission August 2, is based on $17.50 per kw-yr. for secondary power, but calculated on a kilowatt day basis for billing. This is the first Bonneville Power contract submitted to the Commission.

Cooling Congress

MANY INTERESTING FEATURES are incorporated in the World's largest refrigerating plant for air conditioning, as well as the largest central station water cooling plant, which serves the new Capitol Power Plant at Washington, D. C. The six 1000-hp. compressor driving motors are operated by 6600 v., 25 cycle current; and a 150-hp. motor generator set, furnishing 100 kw. provides the excitation for the synchronous driving motors. There are approximately 90,000 lb. of 24-in. steel pipe for water circulation in the machine room alone and eighteen 24-in. valves control the flow of the water in the water coolers.

Driven by the six 1000-hp. compressor motors, this plant will cool over 11,000,000 gal. of water per day. Steam turbine-driven pumps of approximately 1500 hp. draw condensing water from the Anacostia River through more than a half mile of 30-in. pipe. This water is then distributed to the condensers in the plant and finally returned by gravity to the river. In addition, some of these pumps carry the chilled water through the 24-in. diameter supply mains to the air conditioned buildings and return the warmer water to the water coolers, a distance of more than one-half mile each way.

Automatic devices protect the equipment against the danger of chilling the cooling water too low, thus avoiding the possibility of ice forming in the pipes. All the cooling equipment, in addition to the water piping, pumps, temperature recorders and other auxiliary equipment, is contained in a space 120 ft. long by 78 ft. wide, and the net operating height required is 16 ft.

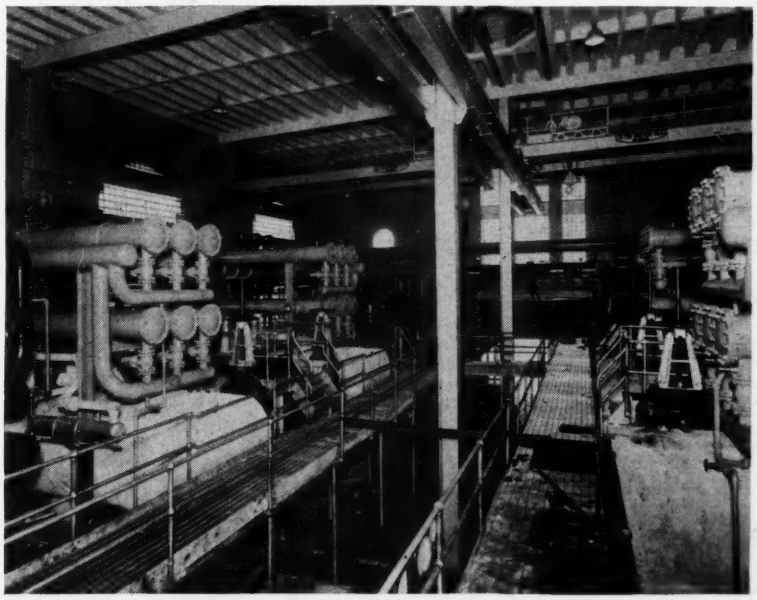
Cooling of the air is accomplished by the circulation of chilled water through coils in the air distributing equipment in the Capitol Office Buildings. A large quantity of water is contained in the closed system consisting of the air conditioning coils in the building, the 24 in. diameter supply and return pipes between power plant and the Capitol Building and the water cooler tanks in the power plant.

In the water coolers, heat is extracted from the continuously circulating water, and the water is delivered at the 24 in. supply pipe at 40 deg. F. While this water is being circulated through the coils in the air conditioners, fans move the air over the coils and the heat passes to the water, reducing the temperature of the air for the comfort cooling of the spaces to be conditioned. This heat from the moving air, having been passed to the water, raises its temperature and the water must again be cooled. This cooling is accomplished by the return of the water to the power plant and recirculation through the water coolers.

Refrigeration equipment in the power plant, which cools circulating water, consists of the compressors, water coolers, and condensers. The refrigerant Freon-12 passes, as a liquid, from the condensers to the water coolers, where it is changed into a gas with the influence of the heat in the circulated water, which heat is thus removed from the water.

The refrigerant is pumped off the coolers by the compressors, and forced under pressure to the condensers. Water drawn from the Anacostia River is passed over the tubes in the condensers and the compressed gas changes to a liquid state and is ready to repeat the cycle.

Construction work of this entire plant was done by the York Ice Machinery Corp., which also manufactures the principal equipment.



For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Refractories

Refractories—Laclede Furnaseal Plastic Fire Brick and Laclede Super Plastic are illustrated and described in a new bulletin recently issued by Laclede-Christy Clay Products Co., St. Louis, Mo.

Unit Suspended Walls—A 20-page booklet divided into three sections giving a general summary in the first section, a comparison with solid masonry in the second with the third devoted to an explanation of Bigelow Engineering standards. The booklet tells why B-L unit suspended walls can eliminate the great efficiency losses of air-infiltration and gives the advantages of complete insulation. Copies of this booklet may be had on request to Bigelow-Liptak Corp., Detroit, Mich.

Refractory—The new Laclede Peerlac Diaspore refractory which combines the high refractoriness of the Diaspore clay with the extreme spalling resistance of the super duty fire clay brick is described in a 4-page folder. Laclede Peerlac is a non-spalling, non-shrinking, slag resisting, power pressed refractory designed for use where very high temperatures, combined with sudden temperature fluctuations, heavy loads, or the action of destructive slags is present. The pamphlet on Laclede Peerlac is available to anyone interested by addressing the Laclede-Christy Clay Products Co., St. Louis, Mo.

Boiler Setting—A new 40-page edition of the catalog Plibrico Furnace Construction for H.r.t. Boilers, covers the subject of boiler setting construction and refractory linings for horizontal return tubular and other types of fire tube boilers. Plibrico Jointless Firebrick Co., 1800 Kingsbury St., Chicago, Ill.

Mechanical Power Transmission

Belting Data Book—A 32-page data book covering transmission, conveyor and elevator belts is one of the most comprehensive ever compiled for use by engineers, plant operators and executives. The data book is full of illustrations and information, easy to read and understand. It includes recommendation tables, recommended cover thicknesses, horsepower tables, types of drives, tables of speeds, ply recommendation, tensions, belting layouts, and other information of use in making proper belting applications. New York Belting & Packing Co., 1 Market St., Passaic, N. J.

Traction Type Hydraulic Coupling is completely illustrated and described in a new 8-page bulletin which was recently issued by the Hydraulic Coupling Division of American Blower Corp., 632 Fisher Bldg., Detroit, Mich.

Bearings—A complete line of Link-Belt Shafer radial-thrust single-row and double-row roller bearings in the naked or unmounted form, are illustrated and described in a new 12-page book, complete with engineering data for figuring applications. The new book gives dimensions, weights, load ratings at 500 r.p.m., and list prices, for both single-row and double-row bearings. Engineering data, such as determination of radial load; load ratings; modifying factors, life factors; operation factors; speed factors; and formulae and examples covering all types of loading, also are included. A copy of this new Book No. 1652 may be obtained by writing to Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

Variable Speed Control—A new 124-page catalog (No. G-384) under this title covers the complete line of Reeves variable speed control equipment in one compact, easy-to-use volume. The entire book is printed in two colors and each of the three sections is printed in a different color combination for ready identification. Ample space is devoted to engineering data on the Reeves Transmission, the vari-speed motor pulley, and motordrive. All dimension drawings are notably large and easy to read. Copies are available from Reeves Pulley Co., Columbus, Ind.

Conveying Equipment

Solving the Problem of Coal and Ashes Handling in the Power Plant is the title of a new Book No. 1510, of 32 pages, copiously illustrated, containing ideas and suggestions for cutting handling costs in the power plant by means of elevating and conveying equipment, coal crushers, etc. A copy of this book will be sent to any interested reader upon request to Link-Belt Co., 300 W. Pershing Road, Chicago, or 2045 W. Hunting Park Ave., Philadephia.

Material Handling Systems—Bulletin No. 138 pictorially illustrates the five essential steps in the selection of material handling systems—survey, design, proposal, installation and maintenance. This is a comprehensive bulletin illustrating the application of conveying machinery to a wide field of industries. A copy of this bulletin may be obtained by writing The Gifford-Wood Co., Hudson, N. Y.

Metal Conveyor Belt—A new 1938 catalog gives a complete description of cyclone metal belt conveyor and construction, application and operating features. Cyclone Fence Co., Waukegan, Ill.

Redler Conveyor—In Volume 180 of the house organ, the Labor Saver, is a story of how efficiently the Redler Conveyor Elevator handles coal and fly ash in the power plant of the Broadmoor Hotel at Colorado Springs, Colo. Stephens-Adamson Mfg. Co., Aurora, Ill.

Coal and Ash Handling Equipment—Bulletin 338 illustrates and describes Fairfield Hilo Storage systems, cylindrical bunker system, methods for feeding boilers and Fairfield ash handling equipment. The Fairfield Engineering Co., Marion, Ohio.

Specialties

Air Ejectors—Steam jet air ejectors designed for air removal, condensation, dehydration, deodorization, distillation, evaporation and impregnation are described in an illustrated leaflet. The different types of ejectors, where and when to use them, and outstanding design features are discussed. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

List Price Schedule R1—A new 44 page List Price Schedule supersedes all previously published list prices and covers the entire line of valves, boiler mountings, lubricating devices which are listed numerically by figure number. These Schedules are available through Lunkenheimer Distributors in all industrial centers and from The Lunkenheimer Co., Cincinnati, O., direct.

The Third Essential in Steam Specialties—A new booklet under this title outlines a practical method for judging how well steam specialty equipment is made to give long service without repairs. It explains which parts are the vital parts, and which materials are especially suitable to make vital parts for different types of service. Twenty-two actual examples are illustrated. The International Nickel Co., Inc., 67 Wall St., New York, N. Y.

Separators—Bulletin S-14-B in color gives a complete treatise of the entire line of Swartwout Separators, each type of separator is described and a table given showing the dimensions and price and specification. The Swartwout Co., 18511 Euclid Ave., Cleveland, O.

Welding

Welding — Three new bulletins under following titles, GEA-2791A, Thyratron Resistance-Welder Controls; GEA-2965, for High-Speed Arc Welding; and GEA-2966, for Cast-Iron Welding, have been issued by General Electric Co., Schenectady, N. Y.

Thermit Welding—This process and its applications are described in a 34-p. booklet, showing its advantages and economies for machine repair and foundry work by Metal & Thermit Corp., 120 Broadway, New York, N. Y.

Welding Aluminum is the title of a tion for the welding of aluminum and tion for the welding of aluminum and its alloys, followed by a brief discussion of the principles involved. Aluminum Co. of America, Pittsburgh, Pa.

Combustion Equipment

Green's Mechanical Draft Fans is the title of a 36 page Bulletin 166 which deals only with types of fans generally used for forced and induced draft principally in steam power plants. These include backwardly and forwardly curved blade fans, straight blade fans and multi-blade fans. Characteristics for each type of blade construction are explained in detail and illustrated by characteristic curves. A copy of bulletin 166 may be had on request to The Green Fuel Economizer Co., Inc., Beacon, N. Y.

Hagan Automatic Combustion Control—A 16-page book, Form 609-R, in color outlines the function, need and history of automatic control, illustrates typical installations, describes in considerable detail the elements involved in a control system. The Hagan Corporation, Pittsburgh, Pa.

Stokers—Bulletins 1004 and 1104 give a complete discussion of the F & E underfeed stoker. Both the commercial and industrial types are claimed by the manufacturer to be the only underfeed stokers with this combination of six vital stoker features: Unit type electro-hydraulic drive; interval timer governor; sliding bottom retort; fuel bed regulator; ram extension; high efficiency tuyeres. Flynn & Emrich Co., Baltimore, Md.

Dust Control

Dust Collection—A new booklet on Industial Dust Collection by the Buell Engineering Compay's Van Tongeren principle has just been completed. Buell Engineering Co., Inc., 70 Pine Street, New York, N. Y.

Dust Control—Bulletin 90 entitled Dust Control by Sly gives an extensive resume of the cloth type filters, their application in many dust control problems as well as other general information concerning dust control equipment and installations. Bulletin 91 covers the Centri-Merge wet dust collector, which has a wide application for certain problems heretofore left unsolved because of inadequate equipment. The W. W. Sly Mfg. Co., 4700 Train Ave., Cleveland, Ohio.

Prime Movers

Turbine Units—A new bulletin, 1191, covers one frame size of a complete line of impulse reaction steam turbine generating units. These turbines contain most of the design features used so successfully in large 3600 r.p.m. turbines. The frame size illustrated and described by this bulletin has been designed for a capacity range of 1000 to 1500 kw. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Diesel—Bulletin 769 in the second edition illustrates and describes Type RHB-100 Diesel Engine which is especially designed for heavy duty continuous service and is built in sizes of 300 to 800 hp. Chicago Pneumatic Tool Co., 6 East 44th St., New York, N. Y.

Steam Turbines—Type C Steam Turbines particularly adapted to driving pumps, forced and induced draft fans, compressors, Jordons, pulp beaters, pulverizers and line shafts are described in a 12-page illustrated booklet, B, 2084-A. They are built in capacities ranging approximately from 5 to 500 hp. at turbine speeds of 100 to 500 r.p.m. Copies of the booklet may be secured from the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

The Universal Unaflow Steam Engine—A 46-page Catalog in colors on coated stock is a treatise on the Universal Unaflow steam engine. It shows 27 patented features and gives 11 salient facts about, and completely describes the condensing and noncondensing types of Unaflow engines. The Skinner Engine Co., Erie, Pa.

Electrical Equipment

Network Protectors is the title of a 24-page illustrated booklet describing light-duty CM-44 toll-out unit network protectors. For better voltage regulation, improved service continuity, decrease in light flicker and extreme flexibility of the a-c. secondary network, this protector may be used in the medium density overhead and lighter density underground areas as the use of heavy appliances and better lighting increases. The booklet describes the application, operation, construction and ratings of these standardized units which have only one sized framework or housing that will take any available ampere changeable between open type, weather-proof or subway type protectors. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Outdoor Switchhouse—Leaflet 2299 describes the many important advantages of this metal enclosed switchgear over open type construction and gives useful dimensions and construction data. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Voltage Regulators—Revised bulletin 1183-A describes type DFR distribution feeder voltage regulators. The principles of operation, major design features, and field of applications are described in detail in this profusely illustrated bulletin. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Rotax Electric Operated Controllers—Bulletin 184-2 printed in two colors on coated stock consisting of 32 pages, illustrates and describes the Foxboro Rotax control system which operates the controlled equipment electrically but not motor driven. The rotating control contacts are directly connected to the measuring system. Foxboro Co., Foxboro, Mass.

Murex Electrodes—These heavy coated electrodes in various types for all purposes are described and proper method of use outlined in a 30-p. booklet by Metal & Thermit Corp., 120 Broadway, New York, N. Y.

Notes On Fault Location In Cables—This 52-page pocket-size book will be useful to anyone interested in fault location—whether in communication transmission, or in electric-power transmission. It gives facts helpful to the tester when locating any of a variety of faults. Illustrated with diagrams, it explains methods for identifying faulty wires in a cable, for measuring conductor resistance, for locating grounds and crosses by Murray and Varley Loop tests, for locating opens by capacitance tests. A copy will be sent to anyone who asks Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa., for Notebook E-53-441.

Miscellaneous

Railway Cars—A new informative, 16 page bulletin 71 describes industrial railway cars and accessory equipment. Copies are available by writing The Koppel Division of Pressed Steel Car Co., Inc., Grant Building, Pittsburgh, or through this publication.

Air-Operated Controllers is the subject of a new folder No. 89-9 in which the adaptability of air-operated controllers to the varied control requirements of industrial processing is demonstrated in a representative list of 50 applications. Several interesting installations are illustrated. A copy of this folder will be sent on request to The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

Fairbanks Platform and Special Trucks are completely illustrated and described in Bulletin 52 showing only the standard designs used by industrial plants, warehouses, retail stores, packing houses, transportation companies, contractors and institutions. The Fairbanks Co., 399 Lafayette St., New York, N. Y.

Copper and Copper Alloys is the subject of an address given before the Baltimore Purchasing Agents' Association by M. G. Steele, Technical Advisor of the Baltimore Division of Revere Copper and Brass, Inc. A chart accompanying the article presents in tabular form a schedule of thirty typical coppers and copper alloys which are more or less fundamental in character. The address, reprinted from Purchasing may be had on request to, Revere Copper and Brass, Inc., 230 Park Ave., New York, N. Y.

Heat Transfer Equipment—Managers and engineers of plants in which process work involves heating or cooling of fluids will be interested in bulletin 1260 on heat transfer equipment for chemical services, which illustrates and concisely lists the outstanding features of more than 20 designs of chemical processes heat exchangers, heaters, coolers, condensers and evaporators, many of which have exclusive forms of heat transfer elements that permit recovery of waste heat or transfer of heat unobtainable in any other design. The bulletin also includes a convenient self-indexing reference table listing the most suitable types of heat exchangers for each special fluid and service. Copies of the bulletin can be obtained by addressing The Griscom-Russell Co., 285 Madison Ave., New York, N. Y.

New Engineering Books

Elements of Steam and Gas Power Engineering. By Andrey A. Potter and James P. Calderwood. Fourth Edition. Size 5½ by 8 in., 374 pp.; 265 illustrations. Cloth bound. McGraw-Hill Book Co., New York, N. Y. Price $2.75.

Prepared as a textbook on the elements of these branches of engineering, the field is surveyed and social significance of power discussed, then methods of producing power and principles of action of various motors analyzed, with comparison of their performance and suitabilities.

One section deals with steam, a second with gas and a third with applications to transportation. After outlining principles, their application, structural details and operation of machinery, problems are given to show application of the instruction given. But little mathematics is employed, the descriptions being designed for those who are starting their study of power machinery, yet the elements are fully covered and a good working knowledge given of the various kinds of equipment.

In this edition the book has been brought up to date as to theory and practice, using the steam tables from Keenan and Keyes, the latest form of Mollier chart, and showing most recent practice in turbines, condensers, auxiliaries and measuring instruments.

Photoelements and Their Applications. By Dr. Bruno Lange. First Edition. Cloth, 6¼ by 9¼ in., 304 pages, illustrated. Reinhold Publishing Corp., 330 W. 42nd St., New York, N. Y., 1938. Price $5.50.

To the layman the electric eye is one of the wonders of the age in which we live and he expects it to be able to do most anything. But there are electric eyes and electric eyes, and those engaged in the electronic art know that there is as much difference in electric eyes as there is in human eyes. We will not go so far as to claim that electric eyes are as fascinating as some pairs of eyes we have been entranced by but they are subject to somewhat better control and considerably safer to play with. Their theory, however, is quite involved and while a number of books have covered the general subject of photo cells, few of them have considered the subject from the standpoint of the internal photoeffect. There are, in general, two types of photoelectric effects, the first the external photoelectric effect used in the alkali, vacuum photocell and, second, the internal photoeffect characterized by the early selenium cell and the modern barrier-layer photocell. It is this latter type that Dr. Lange is primarily concerned with in this book, and his treatise is one of the most comprehensive that has come to our attention.

Dr. Lange, who is a consulting engineer in Berlin, was formerly Research Physicist with the Kaiser Wilhelm Institute of Berlin, and is the inventor of one of the most widely used types of photoelectric equipment. His lifelong study of the subject enables him to write with authority and in this book he presents a clear outline of the basic photoelectric phenomena as well as a detailed discussion of the possiblities for applying this phenomena to scientific and industrial purposes. While certain sections of the book are necessarily mathematical, in general it will not be found too technical for the practical man interested in applying photoelements to specific industrial problems.

Midwest Power Conference Proceedings, Volume 1, 1938. This book of 170 pages contains the papers delivered at the Midwest Power Conference held in Chicago April 13 to 15, 1938, under the sponsorship of Armour Institute of Technology with the cooperation of Iowa State College, Purdue University, State University of Iowa, University of Illinois, University of Michigan, University of Wisconsin and of local and national engineering societies. The price of the Proceedings is $2.00 and may be secured from Stanton E. Winston, Conference Secretary, Armour Institute of Technology, Chicago, Ill. There were a total of 27 papers presented, all of which are presented in the Proceedings with necessary illustrations. The book also contains a registration list of those who attended the Conference and a complete copy of the program.

Managerial Control. By John G. Glover and Coleman L. Maze. Published by the Ronald Press Co., 15 E. 26th St., New York, N. Y. Size 5 by 8 in., 555 pp. cloth bound. Price $4.50.

Less freedom in the adjustment of wages, working hours and competitive practice in industry makes necessary new and better managerial policies if an excessive shrinkage of profits is to be avoided In general the answer to the problem lies in better balance in organization; increased individual effectiveness; elimination of waste; more effective planning through research dependable and inclusive standards and records; and reduction in costs through new and improved methods. Instruments and methods successfully used by industrial executives to bring these variations under control are discussed with specific examples and illustrations added to make the text more understandable.

The treatment is entirely from the standpoint of the executive and is in three parts under the general headings: Organization for Manager Control; Managerial Control of Manufacturing Costs; and Managerial Control of Marketing and Administrative Costs. The 30 chapters cover all phases of industrial activity from general organization, labor and wages, through production, accounting, sales, and advertising.

Many of the problems are, of course, primarily engineering and the control of power. Costs and maintenance costs occupy an important place in the book. It is not an engineering book, however, but a working manual for the general executive. Its value and interest to the engineer, accountant, department manager, etc., lies not in specific information about his own particular function but in showing: his relation to the organization as a whole; the methods available to maintain balance and coordination; and an interpretation of the variation between planned and actual accomplishments.

How to Handle Grievances. By Glenn Gardiner, 52 pp., paper, 45 cents. Elliott Service Co., 219 E. 44th St., New York, N. Y. In this manual, the author itemizes the causes of grievances among workers, outlines his methods of meeting employes and talking over their complaints and gives instances of good and bad handling of grievances. It is well written, compact and to the point.

Sprinkle's Conversion Formulas. By Leland W. Sprinkle. Published by P. Blakiston's Son & Co., Inc., Philadelphia, Pa. Size 4 by 6½ in., 122 pages, flexible, washable fabric binding. Price $1.25.

One of the common and often troublesome problems of engineers is converting units from one system of measurement to another. This need is becoming more and more frequent every day as the use of the metric system of measurement comes into wider use and engineers take more interest in foreign developments. These conversion tables are usually complete and are arranged alphabetically so that the conversion can be made by simple multiplication. The book is in convenient pocket size and will be found of inestimable use to the engineer and physicist.

The Science of Seeing. By Matthew Luckiesh and Frank K. Moss. Cloth. 6½ by 8 in., 548 pages, illustrated. D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, 1937. Price $6.00.

A new book on the science of seeing associated with the name of Matthew Luckiesh needs no recommendation, and when it is also coupled with the name of Moss one can well expect it to be outstanding. For the researches of Luckiesh and Moss have occupied the forefront of exploration in the field of lighting and seeing for so many years that their names have become almost synonymous with lighting progress. As Director of the Lighting Research Laboratory of the General Electric Co. at Nela Park in Cleveland, Dr. Luckiesh has directed the course of lighting advance over a quarter of a century and Frank K. Moss has been associated with him as physicist for many years. It is but natural, therefore, that this new book on the science of seeing should be noteworthy, not only because of the authoritative background the authors' experience affords it, but because for the first time it correlates the results of accumulated research of both lighting and occular science into a unified science of "seeing." Extending far beyond the older subject of vision—

this science attacks the problems of seeing from the broadest standpoint of human efficiency, safety and welfare.

The amount of scientific research which this book represents is enormous. It is filled from cover to cover with a most amazing variety of technical data, charts, graphs, tabulations, etc., gathered from various sources but most of which originated in the Nela Park Laboratory. The presentation of this material, however, is simple and straightforward, understandable to the layman and scientist alike. The book should have a broad appeal and should prove as useful to the ophthalmologist and to the illuminating engineer as it is of general interest to the layman. Of our five senses, the sense of sight is undoubtedly the most valuable and important and it is for this reason alone if for no other that this book should interest everybody. As the authors point out, civilization is largely a matter of seeing. Throughout its intricate pattern seeing is an intimate and important factor in the education, experience and performance of human beings. With each advance in civilization the burdens and responsibilities of seeing increase and as a consequence, year after year, eye defectiveness is mounting. It is in the interest of conserving our rapidly decreasing seeing resources that the authors have written this book and we feel that they have accomplished this remarkably well. It is the most comprehensive attack on the problem ever made.

Inductive Coordination of Rural Power and Telephone Systems was recently issued as publication F2 by the Edison Electric Institute, 420 Lexington Ave., New York, N. Y. Copies are 80 cents each to E. E. I. members and their employees; $2.00 to non-members in the U. S. A. and $2.15 to non-members in foreign countries. The report is by the joint subcommittee on development and research of the E. E. I. and the Bell Telephone System. Methods are described for estimating the inductance of various types and the noise in exposed telephone lines. Coordinative methods applicable to power and telephone systems are discussed.

Elements of Thermodynamics. By Ernest M. Fernald. Published by McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York City. Size 6 by 9 in., 308 pp., cloth bound. Price $3.50.

Although this is marked as the second edition of Professor Fernald's text on Thermodynamics, it is in effect a newly written book giving what the author feels is a better balance. From the standpoint of an elementary textbook on thermodynamics, the new chapters on mixtures, semiperfect gases, combustion and fundamental relations do much to balance the treatment but these new chapters replace considerable material on steam, material which although it may have narrowed the coverage somewhat, made the first edition unique among thermodynamic textbooks as a practical guide to Engineering Thermodynamics applied to the power plant and power plant cycles. The new edition is a complete and well balanced text on fundamental thermodynamics and carries out the author's original ideas as to the logical development of the subject which in some cases differ materially from conventional treatment. The book is divided into 15 chapters, each with a number of problems and review questions at the end and is followed by an appendix with 14 tables of use in thermodynamic calculations.

Pressure Losses Resulting from Changes in Cross-Sectional Area in Air Ducts by A. P. Kratz and J. R. Fellows has recently been issued as Bulletin No. 300 by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. A limited number of copies are available for free distribution after which the regular price of 65 cents a copy will apply. This is a report of an investigation which had for its object the determination of the losses in total head or total pressure, known as "shock loss," and which results from abrupt changes in the cross-sectional area of an air stream, or occurring in various transition sections connecting ducts of different diameters. Losses from abrupt contractions are smaller than those caused by abrupt expansion. Losses in diverging sections increase with the angle and at about 60 deg. the loss is as great as that occurring with an abrupt expansion. This is also true of converging sections, although the loss with a converging angle of 60 deg. is less than that in an abrupt contraction.

How to Run a Lathe, the well-known machinist's manual, in a new 34th edition, has just been announced by the publishers, the South Bend Lathe Works, South Bend, Indiana.

The new edition has been completely revised and the material divided into chapters and sub-headings according to machining operations, beginning with the elementary work, and progressing to the more advanced metal working jobs.

The new book has 128 pages and contains over 350 illustrations, showing practically every type of lathe set-up, and methods for handling all important machining operations. The book has the latest and most authoritative information available on modern lathe practice. Besides dealing with all phases of lathe work, the book also includes a generous amount of general shop information, such as: reference tables and formulae, rules gages, specifications, shop hints, etc.

Originally introduced in 1907 in the form of a 16-page manual, the book has been rewritten and improved each succeeding year until now more than 1,500,000 copies have been printed. Besides the English, the 34th edition of "How to Run a Lathe" is being printed in French, Spanish, Portuguese, Swedish and Dutch. The book is standard instruction in school machine shops in nearly every country.

Copies are 25c each, and will be mailed postpaid anywhere in the world. Stamps or coin of any country are accepted. Copies are available by writing to this magazine or to the South Bend Lathe Works, South Bend, Indiana.

Steels for the User. By R. T. Rolfe. Exclusive agents for North and South America, the Chemical Publishing Co. of N. Y., Inc., 148 Lafayette St., New York City. Size 5½ by 8½ in., 275 pp.; cloth bound. Price $8 50.

From the mass of extremely scientific and technical data on steels, written primarily from the standpoint of the specialist and metallurgist, it is difficult for the user to exercise the proper degree of discrimination and select steels with assurance that they are the best available for a particular use. The author, who is chief metallurgist of Messrs. W. H. Allen Sons & Co., Ltd., of Bedford, England, bridges this gap between science and practice for carbon steels in industry. Alloy steels are not specifically dealt with, although they are discussed in considerable detail in the latter part of the book where the practical limitations of carbon steels for specific uses are discussed. The book is divided into 11 chapters discussing the various aspects of the mechanical qualities, specific requirements, bright and free-cutting steels and the theoretical and practical heat treatment. Fatigue testing and the use of steels at elevated temperatures are of particular interest to the power plant man at the present time and are treated in separate chapters. The last chapter discussing the general principles of selection, although brief, is unusually good and sets forth the practical limitations, advantages and disadvantages of carbon steels for specific purposes, concluding with a discussion of the factors affecting the choice between carbon and alloy steels.

Principles of Engineering Economy. By Eugene L. Grant. Published by The Roland Press Co., 15 E. 26th St., New York City. Size 5 by 8 in., 385 pp., cloth bound. Price $3.75.

To a large extent the usefulness of the engineer is limited by his ability to appreciate the economic aspects of engineering and interpret his plans or justify his course of action in terms of dollars, the only common denominator of all branches of business and business activity. Yet no branch of an engineer's education is so generally neglected. As a result of emphasis on the physical aspects of a problem, the question of ultimate economy over a period of years which is subject to principles quite as definite as physical design, is lost sight of until contact with the business world brings about the realization that it is the deciding factor.

In the first edition principles of cost comparison were illustrated by particular cases instead of abstract mathematical formulae and made an effective handbook for the practicing engineer. As a result of experiment in class work the revised edition is more of a typical text book organized around the general question, "Will it pay?"

The book is divided into four general parts: Planning Engineering Studies to solve engineering problems; Interest—the time element in economy; Techniques for economy studies; Getting results from economy studies. Three appendices include notes on the technique of estimating costs, interest tables and selected references. Problems which formed an integral part of the first edition have been rewritten, increased in number and appear as a separate volume.

Power Plant Construction News

Calif., Glendale—City Council will take bids soon for new 20,000-kw. steam turbo-generator unit and auxiliary equipment for new municipal electric power plant, for which a total fund of about $1,800,000 is being arranged through Federal financing. Closely following, bids will be asked for boiler units and other equipment. Peter Diederich is plant superintendent, in charge.

Calif., Martinez—Associated Oil Co., 79 New Montgomery Street, San Francisco, Calif., plans rebuilding of boiler house and pumping plant at Nichols pumping station, Port Chicago, near Martinez, recently destroyed by fire. Loss estimated close to $30,000.

Fla., Bonifay—Bonifay Ice Co., Bonifay, plans new cold storage and refrigerating plant, and meat-curing plant. Cost over $60,000 with equipment. Proposed to begin work soon. V. C. Lokey is head.

Fla., Clearwater—City Council is arranging fund of about $630,000 through Federal aid for new municipal electric power plant and electrical distribution system, to cost approximately $400,000 and $230,000 in order noted. Plans will be prepared soon.

Ga., Boston—City Council has plans under way for new municipal electric power plant, and cold storage and refrigerating plant. Fund of about $225,000 is being arranged for these and other municipal industrial buildings. Barill & Humphreys, Forsyth Building, Atlanta, Ga., are architects.

Kan., Wellington—City Council has plans maturing for extension and improvements in municipal electric power plant, with installation to include two new boiler units, feedwater heaters and auxiliary equipment. Also, will make extensions in waterworks station, including new equipment installation. Entire project will cost about $200,000. Financing has been arranged through Federal aid. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Mich., Newberry—State Department of Institutions, State House, Lansing, has plans maturing for new steam-electric power plant at Newberry. Proposed to begin work soon. Cost about $348,000, with equipment, of which $157,000 has been secured through Federal grant. Derrick Hubert, 1065 Sheridan Road, Menominee, Mich., is architect; E. R. Little Co., Inc., Ford Building, Detroit, is consulting engineer.

Minn., Madison—City Council plans expansion and improvements in municipal electric power plant, including installation of new generator unit and auxiliary equipment. Cost reported over $85,000. Financing will be arranged through Federal aid. Perkins & McWayne, Paulton Block, Sioux Falls, S. D., are consulting engineers.

Minn., Worthington—City Council has preliminary plans under way for new municipal electric power plant. Cost estimated close to $150,000. Proposed to arrange financing through Federal aid. Ralph D. Thomas & Associates, 1200 Second Avenue South, Minneapolis, Minn., are consulting engineers.

Miss., Jackson—W. G. Avery Body Co., Jackson, manufacturer of automobile bodies and parts, plans installation of electric power equipment in new one-story plant on local site, for which superstructure will begin soon. Entire project will cose about $100,000.

Mo., Macon—City Council has plans under way for expansion and improvements in municipal electric power plant, waterworks station and system, with installation of equipment for increased capacity. Cost estimated close to $200,000. Financing is being arranged through Federal aid. Baumes Engineering Co., Railway Exchange Building, St. Louis, Mo., is consulting engineer.

Neb., Cozard—City Council has plans under way for new municipal electric power plant and electrical distributing system. Cost about $300,000. Financing is being arranged through Federal aid. C. Robert Fulton, 2327 South Nineteenth Street, Lincoln, Neb., is consulting engineer.

N. J., Hillside—Mundet Cork Corporation, 501 Bloy Street, Hillside, plans installation of electric power equipment in new addition to cork products insulation - manufacturing plant. Entire project will cost close to $90,000. Main offices of company are at 65 South Eleventh Street, Brooklyn, N. Y.

N. Y., Long Island City—New York & Queens Electric Light & Power Co., 28-19 Bridge Plaza, Long Island City, New York, has secured permission to dispose of preferred stock issue to total $875,000, proceeds to be used for extensions and improvements in steam-electric generating plant, power substations, transmission and distributing lines, and other facilities.

Ohio, Martins Ferry—City Council has plans in progress for expansion and improvements in municipal electric power plant and waterworks station, with installation of additional equipment. Cost estimated close to $75,000. Financing is being arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ohio, Piqua—City Council has plans under way for expansion and improvements in municipal electric power plant, including installation of additional equipment. Cost about $480,000. Financing is being arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Okla., Cherokee—City Council has arranged financing through Federal aid for new municipal electric power plant, using Diesel engine-generator units and accessory equipment. Cost close to $130,000. Proposed to begin work in near future.

Okla., Healdton—Shell Petroleum Corporation, Shell Building, St. Louis, Mo., plans installation of power equipment, tanks, compressors and other equipment in connection with remodeling and improving natural gasoline plant at Healdton, Carter County, with facilities to more than double present output. Cost reported over $100,000. Company engineering department, Mayo Building, Tulsa, Okla., is in charge.

Okla., Salina—Grand River Dam Authority, City Hall, Vinita, Okla., R. V. L. Wright, general manager, plans new hydroelectric generating plant on Grand River, near Salina, including power dam, generating station, power substations and transmission lines. Entire project estimated to cost close to $4,500,000. Financing is being arranged through Federal aid. Holway & Neuffer, 302 East Eighteenth Street, Tulsa, Okla., are consulting engineers.

Ore., Klamath Falls—Miller Meat Packing Co., Klamath Falls, plans installation of electric power equipment in connection with rebuilding of portion of plant recently destroyed by fire. Loss estimated close to $100,000.

Texas, Crosbyton—Common Council plans new municipal electric power plant, using Diesel engine-generator units and accessories. Also, distributing lines. Cost about $90,000. Financing is being arranged in part through Federal aid. Municipal Engineering & Finance Co., Mercantile Building, Dallas, Texas, is consulting engineer.

Texas, Houston—Chipman Chemical Co., Inc., 401 Yale Street, Houston, plans installation of electric power equipment in new sulphur grinding mill on site now being selected. Entire project will cost close to $200,000.

Va., Galax—City Council has plans maturing for new municipal electric light and power plant, estimated to cost about $285,000, with distributing lines. Federal grant of $129,000 has been secured and remainder of fund will be arranged through municipal bond issue.

Wash., Seattle—Bureau of Water and Power, City Hall, Seattle, has plans under way for new municipal hydroelectric generating plant at its Ruby Dam power site, Whatcom County, estimated to cost about $5,135,000, with transmission line to city. Financing will be carried out through Federal loan and grant.

W. Va., Millville—Potomac Edison Co., Hagerstown, Md., is considering early rebuilding of hydroelectric generating plant at Millville, recently destroyed by fire, caused by lightning. Loss estimated about $250,000, including equipment.

W. Va., Nitro—American Viscose Corporation, 200 Madison Avenue, New York, N. Y., plans installation of electric power equipment in new additions to rayon mill at Nitro, comprising several units to double present capacity. Entire project will cost in excess of $750,000. Proposed to begin work soon.

W. Va., Weirton—Weirton Steel Co. plans installation of electric power equipment in new additions to local mill, comprising several units for large increased output. Entire project will cost about $5,000,000, and is scheduled for completion in July 1939. Company engineering department will be in charge. Company is affiliated with the National Steel Corporation, Grant Building, Pittsburgh, Pa.